TWENTY-SECOND ANNUAL REPORT

OF THE

358
17 JUN 1930

NEW JERSEY STATE

Agricultural Experiment Station

AND THE

FOURTEENTH ANNUAL REPORT

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING

October 31st, 1901.

TRENTON, N. J.
THE JOHN L. MURPHY PUBLISHING CO., PRINTERS.
1902.

TABLE OF CONTENTS.

TABLE OF CONTENTS.

		PAGES.
I.	BOARD OF MANAGERS	xv
II.	ORGANIZATION OF THE NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS	xv
III.	REPORT OF THE TREASURER	xvii
IV.	REPORT OF THE DIRECTOR	1
V.	REPORT OF THE CHEMISTS	15
	Fertilizers	17
	Market Prices of Fertilizers	17
	Chemical Examination of Fertilizers	22
	Introduction	22
	Fertilizer Law	22
	Securing of Samples	23
	Selection of Samples for Examination	24
	Manufacturers	24
	Chemical Analysis	26
	Trade Value of Fertilizer Ingredients for 1901 and Examination of Standard Materials Supplying them	27
	Average Cost per Pound of Plant-Food Constituents	29
	Purchase of Fertilizer Ingredients	30
	Unit System of Purchase	32
	Chemical Analyses of Fertilizing Materials	33
	Nitrate of Soda	33
	Sulfate of Ammonia	33
	Dried Blood and Ammonite	33
	Dried and Ground Fish	33
	Tankage and Ground Bone	34
	Hair Manure	34
	Plain Superphosphates	35
	Muriate of Potash	35
	Sulfate of Potash	35
	Kainit	35
	Examination and Valuation of Manufactured Brands, Home Mixtures, Special Compounds and Miscellaneous Products	36
	Complete Fertilizers	36, 50
	Home Mixtures and Special Compounds	44, 70

V. REPORT OF THE CHEMISTS—*Continued.* PAGES.
Ground Bone.............................. 46, 72
Miscellaneous Fertilizers 48, 74
Sundry Materials........................... 76
Appendix 77
Fodders and Feeds............................... 78
Concentrated Feeding Stuffs........................ 78
Requirements of Law......................... 78
Reasons for the Law......................... 79
Sampling and Analyses....................... 82
Feeds Received and Analyzed.................. 83
Classification of Feeds...................... 84
Average Analyses and Prices of Feeds............ 85
Chemical Analyses of Feeds.................... 87
Protein Feeds............................ 87
Carbohydrate Feeds........................ 95
Feeds Made from Whole Grains............... 102
Poultry, Stock and Condimental Feeds........ 105
Guarantees 107
Actual Composition............................ 113
Selling Prices 125
Selection of Feeds............................ 126
Average Analyses of Fodders and Feeds.............. 129
Market Prices of Commercial Feeds................. 135
Nitrogen Investigations................................ 137
Availability of Organic Nitrogen in Raw Materials..... 137
Investigations Relative to the Use of Nitrogenous Materials 144
Oat Experiment 154
Corn Experiment............................... 170
Review of the Investigations Concerning Denitrification, 183
VI. REPORT OF THE ASSISTANT IN SOIL CHEMISTRY AND BACTERIOLOGY, 211
VII. REPORT OF THE ASSISTANT IN HORTICULTURE.................... 215
Daily and Monthly Rainfall for 1901...................... 218
Permanent Experiment Plots.............................. 219
Asparagus 221
Blackberries 225
Raspherries 227
Currants and Gooseberries........................... 229
Strawberries 232
Varieties 234
The Tree Fruits..................................... 238
General Treatment.............................. 239
Plums and Cherries............................. 240
Dwarf Pears.................................... 241
Standard Pears................................. 243
Peaches 244
Varieties.................................. 251

VII. REPORT OF THE ASSISTANT IN HORTICULTURE—*Continued.* PAGES.
Methods of Setting.......... 253
Bush Fruits.......... 254
New Varieties.......... 255
Sub-Irrigation 256
Vegetables 257
Beans 258
Peas 260
Tomatoes 262
VIII. REPORT OF THE ASSISTANT IN DAIRY HUSBANDRY.......... 269
Summary of Work.......... 271
Soiling Crops 272
Special Crops.......... 276
Cow Peas and Corn as a Silage Crop.......... 276
The Right Lap Cutaway.......... 277
Seeding Grass without Grain.......... 277
Oat and Pea Feed and Straw *vs.* Oat and Pea Hay.......... 278
Yield of Milk and Fat.......... 279
Composition of the Milk.......... 282
Cost of Milk and Butter from the Two Rations.......... 282
The Individual Animals.......... 284
The *Building of Farm Roads*.......... 284
Roads Made of Cinders.......... 285
Roads Made of Cinders and Gas Lime.......... 285
Roads Made of Cinders and Stone Lime.......... 285
Description of the New Wing of the Dairy Barn.......... 286
Cost of Producing Milk.......... 287
Soiling Crop Rotation.......... 291
The Dairy Business in Relation to Soil Exhaustion.......... 293
Records of the Dairy Herd for the Year.......... 295
Wastes in Handling and Delivery.......... 303
IX. REPORT OF BIOLOGIST FOR 1901..........305-381
Part I.—*Scientific Studies of Oyster Propagation*..........*307–350*
Oyster Experiment Station and Legislation.......... *308*
General Work of the Season.......... 309
Fertilizing Eggs.......... 310
Culture Tanks.......... 311
Failure of "Sets".......... 312
Description of Oyster Eggs.......... 314
Impregnation of Eggs.......... 317
Polar Globules 318
Segmentation 320
Journal of Operations..........322–330
Effect of Temperature. Table I.......... 330
Table II. Preparations 332
Technique 333

IX. Report of Biologist for 1901—*Continued.* PAGES.
Plate I. Constituents of Egg.................... 336
" II. Egg Before Fertilization................ 338
" III. Egg During Impregnation................ 340
" IV. Formation of Polar Globules............ 342
" V. Union of Pronuclei..................... 344
" VI. First Cleavage Plane.................... 346
" VII. Second Cleavage Plane.................. 348
" VIII. Later Segmentation Stages.............. 350
Part II.—Contributions to Our Knowledge of Bovine Tuberculosis 352–381
Autopsy of Number 18............................ 352
Autopsy of Number 59............................ 353
Remarks on Tables............................... 354
Table III. Abortions 356
" IV. Special Tests.............................. 357
" V. Temperatures of Tuberculous Cows and their Offspring 358–381
X. Report of the Botanist...............................382–460
Outline of the Subjects Considered...................385, 386
The Experiment Area...........................386, 387
Experiments with Turnips 388
Potato Experiments in 1901......................388, 389
Experiments with Beans..........................389, 390
Experiments in Crossing Lima Beans.............390–392
Experiments with Tomatoes......................392–396
Crossing Tomatoes 392–395
Tomato Stock Plants 395, 396
Experiments in Crossing Cucumbers................ 396
Notes on Cucumbers..............................397, 398
Experiments in Crossing Eggplants................398–400
Experiments in Crossing Sweet Corn..............400–408
Crossing with Red Grains....................400–403
Crossing with White and Black Grains.........403, 404
Inbreeding of the Crossed Corn................404–406
Wide Pollination in Crossed Corn.............. 406
Breeding of Corn for Prolificness..............407, 408
Experiments with Salsify Hybrids.................408–410
Other Crossing 410, 411
Plant Breeding and Improvement in Our Experiment Stations 411–419
Experiments with Salad Plants.................... 419
Experiments with Weeds.......................... 420
Experiments with Lawn Grasses.................... 421
Experiments with Ornamental Plants..............421–424
Experiments with Phloxes and Their Allies....422–424
Various Polemoniaceæ......................... 424
Experiments with Spraying.......................424–426

X. Report of the Botanist—*Continued.* PAGES.
Kerosene Emulsion 425, 426
Soda Bordeaux and Paris Green.................... 426
The Asparagus Rust....................426–429
Asparagus Rust on the College Farm....................429, 430
Experiments with Pear Blight....................430–433
Root Parasites 434, 435
Broom-Rape Upon Tomato....................435, 436
Ergot Upon Grass 436
Notes Upon Corn Smut 437
The Blight of Cucumbers....................437, 438
The Mildew of the Grape.................... 438
Tulip Mould 438–440
Fungi as Related to Weather....................440–442
The New Greenhouse.................... 442
Seedless Tomatoes 442–445
A Study of Dimorphism in Buckwheat....................445–448
Spraying Experiments in Greenhouse....................448, 449
Albinism in Sweet Corn....................449–451
A Study of Dodders....................451–454
Notes Upon Dodder....................454–457
Self-Fertility in Bush Beans.................... 457
The Dwarfage of Beans by Cutting the Seeds.................... 458
The Simple-Leaved Ampelopsis.................... 459
XI. Report of the Entomologist....................461–587
General Review 463–507
Caterpillars 463
Fall Web Worm.................... 464
Probabilities 465
Remedial Measures 465
White-spotted Tussock Moth 466
Probabilities 466
Remedies and Preventives 467
Catalpa Sphinx 467
Tomato-hawk Moth 467
Swallow-tail Butterflies 468
Plant Lice 468–475
Currant Louse 469
Apple Lice 469
Woolly Apple Lice.................... 469
Strawberry Lice 469
Melon Lice 470
The Cherry Louse *470*
Woolly Maple Louse 470
Phylloxera on Hickory 470
The Pea Louse 471
Scales 475–480
Oyster-shell Bark-louse 475

XI. REPORT OF THE ENTOMOLOGIST—*Continued.* PAGES.
Euonymus Scale 476
Tulip Soft Scale 476
The Rose Scale 476
San Jose Scale 477
Shade Tree Insects 480
The Wood Leopard Moth 480
Maple-leaf Stalk-borer 481
Bag-worms 481
Orchard Insects 483
Rosebugs 483
Silky June Beetles 483
Plum Curculio 484
Sinuate Pear Borer 484
Pear Midge 485
Insects on Field Crops 486
Hessian Fly 486
Angoumois Grain Moth 488
Insects on Truck Crops 489
Rhubarb Beetles 489
Asparagus Beetles 489
Tortoise Beetles 489
Mealy Bug on Sweet Potatoes 489
Potato Beetle 490
An Injurious Root Chafer 490
Cranberry Insects 491
Mosquitoes 491
Insecticide Compounds 492–501
Arsenate of Lead 492
Whale Oil Soap 493
Tobacco Extract (Rose Leaf) 493
"Yankee Yellow" 493
Pyrox 493
Hammond's Thrip Juice 493
Kretol 493
Petroleum 493
Whale Oil Soap 494
Crude Petroleum 494–501
New Beneficial Insects 501
The Result 503
Results Aimed At 504
A Natural Introduction 504
Miscellaneous 505
State Entomologist 505
The Collection 506
Assistance 506
Pan-American Exhibit 506
Haseltine's Insect Trap 506

XI. *Report of the Entomologist*—*Continued.* PAGES.

Insects in the Crop Bulletin........................507–510
Cranberry Katydids and Grasshoppers.............511–526
Experience with Locust Disease.................. 511
Field Record 517
Life History 521
Eggs and How Laid.............................. 521
Remedial Measures 524
The Species 526
Mosquitoes 526–587
Mosquitoes and Malaria 532
Health Board Reports 535
How Mosquitoes Bite 538
Remedies 542
Repellants 542
How Long Do Mosquitoes Live?...................... 543
The Species of Culex.............................. 544
Life History 548
The Salt-marsh Mosquito 549
Breeding Places 551
How Do the Insects Spread?..................... 555
The House Mosquito 559
Other Species of Culex............................ 561
The Species of Anopheles 563–576
Life History 565
Where Does Anopheles Breed?.................... 569
The Spread of Anopheles........................ 572
How Does Anopheles Hibernate?.................. 572
Other Mosquitoes 576
Psorophora Ciliata 576
Conchyliastes Musicus 578
Aedes Species 578
Corethra Brakeleyi 579
Remedial Measures 579

To His Excellency Foster M. Voorhees, LL.D., Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the twenty-second annual report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter CVI. of the laws of that year.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 30th, 1901.

To His Excellency Foster M. Voorhees, LL.D., Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the fourteenth annual report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

AUSTIN SCOTT,
President.

NEW BRUNSWICK, N. J., November 30th, 1901.

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS,

NEW BRUNSWICK, N. J.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

HIS EXCELLENCY FOSTER M. VOORHEES, LL.D., Trenton, Governor of the State of New Jersey.
AUSTIN SCOTT, PH.D., LL D., . . New Brunswick, President of the State Agricultural College.
EDWARD B. VOORHEES, SC.D., . Professor of Agriculture of the State Agricultural College.

FIRST CONGRESSIONAL DISTRICT.

EPHRAIM T. GILL, . . . Haddonfield.
ROBERT GWYNNE, . . Salem.

SECOND CONGRESSIONAL DISTRICT.

WINFIELD S. BONHAM, . . Shiloh.
JOHN E. DARNELL, . . Masonville.

THIRD CONGRESSIONAL DISTRICT.

DAVID D. DENISE, Pres., . . Freehold.
JAMES NEILSON, . . . New Bruswick.

FOURTH CONGRESSIONAL DISTRICT.

SAMUEL B KETCHAM, V. Pres., Pennington.
GEORGE FRITTS, ... Pattenburg.

FIFTH CONGRESSIONAL DISTRICT.

JOSIAH KETCHAM, . . . Belvidere.
JAMES A. BURNETT, . . . Hilton.

SIXTH CONGRESSIONAL DISTRICT.

ABRAM C. HOLDRUM, . . Westwood.
GEORGE H. BLAKELEY, . Paterson.

SEVENTH CONGRESSIONAL DISTRICT.

GEORGE E. DE CAMP, . . . Roseland.
CYRUS B. CRANE, . . . Caldwell.

EIGHTH CONGRESSIONAL DISTRICT.

GEORGE DORER, ... East Orange.
IRA C. KILBURN, . . . South Orange.

NINTH CONGRESSIONAL DISTRICT.

RYNIER J. WORTENDYKE, . Jersey City.
LUCIUS F. DONOHOE, M.D., . Bayonne.

TENTH CONGRESSIONAL DISTRICT.

JOHN B. WILLIAMS, . . . New Durham.
PHILIP M. BRETT, . . . Jersey City.

STAFF.

EDWARD B. VOORHEES, SC.D., . . . Director.
IRVING S. UPSON, A.M., ... Chief Clerk; Secretary and Treasurer.
LOUIS A. VOORHEES, A.M., . . . Chief Chemist.
JOHN P. STREET, M.SC., ... Associate Chemist.
ALVA T. JORDAN, B.SC., ... Assistant in Horticulture.
CLARENCE B. LANE, B.SC., . . . Assistant in Dairy Husbandry.
JACOB G. LIPMAN, A.M., ... Soil Chemist and Bacteriologist.
WILLIAM P. ALLEN, B.SC., . . . Assistant Chemist.
MARY A. WHITAKER, ... Stenographer and Typewriter.
VINCENT J. CARBERRY, ... Laboratory Assistant.
HARRY W. WILLIAMS, ... Janitor.

---

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

BOARD OF CONTROL.

The Board of Trustees of Rutgers College in New Jersey.

EXECUTIVE COMMITTEE OF THE BOARD.

AUSTIN SCOTT, PH.D, LL.D., President of Rutgers College, Chairman, . . New Brunswick.
HON. HENRY W. BOOKSTAVER, LL.D., ... 24 East 64th Street, New York City.
HENRY R. BALDWIN, M.D., LL.D., ... New Brunswick.
JAMES NEILSON, ... New Brunswick.
PAUL COOK, ... Troy, New York.
WILLIAM H. LEUPP., ... New Brunswick.

STAFF.

EDWARD B. VOORHEES, SC.D., ... Director.
JULIUS NELSON, PH.D., ... Biologist.
BYRON D. HALSTED SC.D., ... Botanist and Horticulturist.
JOHN B. SMITH, SC.D., ... Entomologist.
JAMES A. KELSEY, M.SC., ... Field Assistant.
IRVING S. UPSON, A.M., ... Disbursing Clerk and Librarian.
AUGUSTA E. MESKE, ... Stenographer and Typewriter.

THE COLLEGE FARM.

The Trustees of the College give the Stations the use of seven acres of land for experiments in Horticulture and Botany, and the remainder of the farm (90 acres), well stocked and equipped, for experiments in Dairying. The income from the dairy pays for the labor and maintenance of the farm, and in part for dairy experiments.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey State Agricultural Experiment Station, November 1st, 1900, to October 31st, 1901.

APPROPRIATION FOR SALARIES AND EXPENSES.

RECEIPTS.

From State Treasurer	$15,000 00

PAYMENTS.

Salaries and pay of chemists and assistants	$9,601 26
Expenses of the Board of Managers	61 86
Stationery	122 61
Printing	272 82
Postage	195 45
Furniture	[illegible] 35
Fuel	445 84
Gas, electricity and water	237 78
Laboratory expenses	254 04
Field and feeding experiment expenses	1,665 30
Freight, express and cartage	131 61
Expenses collecting samples of fertilizers	521 58
Traveling expenses	194 30
General fittings, repairs and improvements	1,073 72
Insurance	54 09
Reference books	107 24
Contingent expenses	12 65
	$15,000 00

APPROPRIATION FOR CARRYING OUT THE PROVISIONS OF "AN ACT CONCERNING THE REGULATION OF THE SALE OF CONCENTRATED COMMERCIAL FEEDING STUFFS."

RECEIPTS.

From State Treasurer	$3,000 00

PAYMENTS.

Salaries and pay of chemists and assistants	$1,617 33
Stationery	116 18
Printing	431 08
Postage	21 80
Laboratory fittings, apparatus and supplies	547 64
Expenses collecting samples of feeding stuffs	202 94
Reference books	13 03
	$3,000 00

APPROPRIATION FOR PRINTING BULLETINS.

RECEIPTS.

From State Treasurer	$1,000 00

PAYMENTS.

For printing bulletins	$1,000 00

Respectfully submitted,

IRVING S. UPSON,
Treasurer.

The Auditing Committee of the Experiment Station have examined the accounts of the Treasurer of said Station, and have found them correct.

JOHN E. DARNELL,
GEORGE E. DE CAMP,
Auditing Committee.

NEW BRUNSWICK, N. J., January 11th, 1902.

FINANCIAL STATEMENT.

THE TRUSTEES OF RUTGERS COLLEGE

FOR

THE NEW JERSEY STATE AGRICULTURAL COLLEGE EXPERIMENT STATION

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATION, 1900-1901.

		Dr.
To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1901, as per act of Congress approved March 2d, 1887		$15,000 00
By Salaries	$9,460 00	
Labor	1,148 52	
Publications	1,176 41	
Postage and stationery	212 48	
Freight and express	70 77	
Heat, light and water	309 94	
Chemical supplies	83 39	
Seeds, plants and sundry supplies	125 64	
Fertilizers	65 90	
Feeding stuffs	267 01	
Library	660 16	
Tools, implements and machinery	7 75	
Furniture and fixtures	14 97	
Scientific apparatus	426 62	
Live stock	35 00	
Traveling expenses	313 19	
Contingent expenses	166 77	
Building and repairs	457 48	
Total		$15,000 00

We, the undersigned duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th, 1901, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2d, 1887.

Signed, AUSTIN SCOTT,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

The work of the Stations (State and College) the past year has been enlarged mainly in two directions. First, the required inspection and analysis of commercial feeds; and second, the scientific study of oyster propagation. The chemical work has also been reorganized, and a laboratory provided for the chemical and bacteriological study of soils. The work that is regarded as of more direct and immediate use to farmers has not been reduced by virtue of the larger field of scientific investigation, and the continued appreciation by the public of the results obtained by the Stations, is shown both in the constantly increasing demand for their publications and for direct information as to specific needs.

The Analyses of Commercial Fertilizers.

The inspection this year has required the analyses of 314 samples of different brands of complete fertilizer, 25 of ground bone, and 37 of miscellaneous products. There has been one case of direct adulteration discovered, and many, as in the past, where at the prices charged per ton, plant-food is furnished at an exorbitant cost, though the manufacturers have adhered closely to their guarantee. In other words, a careless purchase may result in what is virtually as bad as direct fraud. A study of the work of the year also shows a tendency on the part of consumers to purchase in special lots or special brands made to their order, rather than regular brands, which accounts in part for the larger number examined. Owing to a decision on the part of the company which controls a number of the plants for the manufacture of fertilizers, to withhold statistics as to sales, no definite information is obtainable as to the growth of the industry the past year, though the wide distribution of brands would seem to indicate that there has been no decrease in consumption, but rather a considerable increase. In many sections of the State, farmers' clubs and other organizations, as a direct result of the Station's sug-

gestions, are purchasing their goods either in the form of raw materials or as manufactured brands made directly for their use. In one or two instances, 600 tons or more are purchased in one order, though the amounts range from a carload up. In the purchase of brands made according to a formula furnished to the manufacturer, agents' prices are usually obtained, hence the saving ranges from $5 to $8 per ton, or an average of 25 per cent., while in the purchase of raw *materials the saving in the cost of plant-food is often still greater.* The business-like manufacturers are eager for this trade, as payments are usually made partly cash on delivery, and the remainder on short time, a saving to them of both capital and agents' expenses. Wherever this system of purchase is practiced, it is the experience of farmers that the goods give quite as satisfactory results as do the regular brands put up by the manufacturers. In other words, the reduction in cost is not accompanied by a reduction in quality of plant-food. The average of all of the manufactured brands purchased in the regular way shows that the cost of plant-food is less than in 1900, or, in other words, that the charges for mixing, bagging and handling are lower.

The tables of analyses also show 59 samples of standard products, 18 special mixtures and 8 home mixtures. A reduction in the number of samples over those found in many previous years, and due largely to the tendency already pointed out of farmers purchasing goods made according to their formulas and from materials which they have selected. It is an illustration of the better knowledge on the part of the farmers in reference to what constitutes a fertilizer, and that other things being equal, the price per pound of the constituent is a safe guide in such purchase. The investigations which have been conducted by the Station for years on the economy in the purchase and use of fertilizing materials, have resulted in recommendations to purchase the raw materials and mix for themselves, rather than pay the charges made for mixing, handling and selling, have been largely responsible for the change from that method to the present one, now more largely used. Farmers in certain localities have begun, first, with a small purchase and use of raw materials, have determined the effectiveness and profitableness of such purchase and use, and the knowledge thus gained has had a tendency both to increase the use of plant-food from year to year and to enable the purchase of the mixed materials in an intelligent and business-like way. *They know how to purchase their materials at quite as* low a price per pound without the intervening trouble of preparing

and mixing their own mixtures. There is one point, however, which the Station is obliged to insist upon, and that is, that individual farmers or clubs in purchasing goods should confine themselves to fewer brands, that is, to use one for various crops, provided they desire to have their individual purchases analysed. The Station has offered to make analyses in cases where 20 tons or more are purchased, for unless as large a quantity as this is represented, the work of the Station becomes in part, at least, an individual rather than a public matter, and the Station cannot under any circumstances make analyses, the results of which may be regarded as of a private nature.

The very large amount of work involved in the inspection and analyses of fertilizers in recent years, has been made possible because of improvements in the methods of analyses, which has materially shortened the time required for many determinations. This work is of the highest importance, and the chemists devote much time to such study—the results are rather reported to the Association of Official Agricultural Chemists than published in full as a part of the work of the Station.

This year much time has been devoted to the collating and study of methods for the analysis of insecticides, and to the investigation of methods devised for determining the quality of the organic nitrogen as it exists in the regular brands of fertilizers. This latter investigation is of primary importance, and so much has been accomplished as to lead to the hope that a practicable method may soon be devised and adopted.

The Analyses of Commercial Feeds.

Chapter 29 of the Laws of 1900 invested the Experiment Station with the inspection of commercial feeds. The importance of a law of this kind has been previously pointed out, and the results obtained from the inspection of last year abundantly verify the arguments made in its favor. Bulletin No. 153, issued as a result of the first inspection and analysis, shows that a wide variation exists in the composition of feeds upon the market offered under the same general name, and that there is a very great need of the knowledge of the composition of these special brands, as well as of those of a more concentrated character, in order to enable an intelligent purchase. This bulletin gives this information, together with suggestions as to the kind and character of the supplies needed under average conditions, besides it contains the analyses of 469 samples, representing 65 different kinds of feed, and though these may be classified in four

groups, wide variations exist in the analyses of the samples of each group. The bulletin was prepared with great care, and the various points of interest discussed in much detail, aud information given which is of value to the producer, the purchaser and the general reader. The principles underlying the selection of feeds are clearly pointed out, and the necessity for a careful comparison of the different products offered strongly urged, as well as that the purchaser should clearly discern between commercial and nutritive values. It is gratifying to note, that even in this first year of the operation of the *law, that the leading manufacturers and dealers are thoroughly in* accord with the provisions of the law, and are not only willing to comply, but stand ready to assist in every way possible, knowing that their interest lies, as does that of the fertilizer manufacturer, in the education of the farmer in reference to true values. Progressive work of this character is of great usefulness, and owing to the present organization of tbe Station, it is obtained for tbe public at a very small cost to the State.

In addition to the analyses of commerical feeds, a number of samples of *forage and farm* crops, grown *for the* purpose of studying their adaptability and usefulness, have been examined and tabulated in the body of the report, together with a table showing the average composition of the feeds, fodders and forage crops grown and sold in the State.

Plant Nutrition.

These studies begun in 1898, have been carried on with every scientific precaution, and results of far-reaching importance have already been obtained. The data obtained and a discussion of the purely scientific phases of the work have been published from year to year. The practical value of an application of results secured seemed, however, to be of such immediate importance to the farmers, particularly in the handling and use of home manures, that a study of all of the data bearing upon this point was made and the results published in Bulletin No. 150, entitled "I. Losses in Farm Manures. II. The Relative Usefulness of the Nitrogen in Fresh and in Leached Manures. III. The Comparative Value of the Nitrogen in Commerical Forms and in Natural Manures." Tbe results obtained this year, though not yet fully tabulated, are striking and confirm in a remarkable manner, with wheat and rye, those obtained with oats and corn. One branch of this investigation has for its object to determine whether denitrification (the setting free of combined

nitrogen) occurs in the combined use of nitrates and organic nitrogenous materials ; thus far the results do not show marked losses in this direction, and in order that the whole matter may be on record, a historical sketch, showing the growth and development of this line of investigation and results obtained, together with a bibliography have been incorporated in this report.

In addition to the more scientific phase of the subject, field experiments with eleven of the leading market garden crops of the State were carried out to study the practical side of the question of nitrogen asssmilation and results were obtained of great practical value, though they are not ready for incorporation in this report.

HORTICULTURE.

In this department the field work has been very materially increased owing to the fact that most of the varieties fruited this year, thongh the season was not as favorable for large crops as in 1900.

The very great usefulness of experiments which show the advantage of a careful selection of varieties is apparent in the results secured again this year. For example, in a comparison of the value of the crops of all of the known varieties of aspargus, it is shown that the valne per acre of the best variety is $284 greater than that of the poorest variety under identical conditions of soil and treatment. The same is true in regard to blackberries—gains of over 100 per cent. in the value of crops are shown to exist between the best and the poorest variety, while in the case of raspberries, currants and strawberries, the gain is even greater. In the case of tree fruits, an insufficient number of crops have been received to enable a strict comparison of the value of different varieties or methods of treatment.

The results of the study of methods of fertilizing and manuring are also very important and show very positively that for asparagus particularly, commerical fertilizers may be used to substitute yard manures, the yields obtained are greater and the cost of material and labor less.

The experiments on the irrigation of asparagus and small fruits have been continued, and in the case of blackberries, gooseberries, raspberries and currants, the advantage of the added water is very noticeable. These studies in connection with those in other parts of the State with small irrigation plants in co-operation with the United,

States Department of Agriculture, have given results of much value concerning the practicability of irrigation in the humid districts.

Studies in the forcing-house have been continued, mainly with cauliflower, lettuce, tomatoes and cucumbers, both as to the varieties of the plants best adapted for the purpose, as well as concerning methods of treatment and feeding.

DAIRY HUSBANDRY.

In this department the investigations have been continued mainly along the line of the adaptability and usefulness of varieties of forage crops, as well as concerning the establishment of forage crop rotations. All of the leading varieties of plants generally used or recommended for this purpose have been studied, and in many cases the rotation has been such as to enable the growing of three different crops per acre per year, with a yield in some cases exceeding 25 tons. The experiments have also been continued with protein crops, as cow peas, oats and peas, and alfalfa, for the purpose of determining their usefulness as substitutes for expensive concentrated protein feeds. The very great increase in price of feeds in the past year renders this line of experimentation particularly useful.

The experiments with alfalfa have been continued and large yields have been obtained. Field experiments in growing alfalfa, and feeding experiments to determine whether alfalfa protein might substitute the protein of wheat bran and dried brewers' grains were carried out, and the results reported in Bulletin No. 148 showed the great value of this plant, where it can be successfully grown, and that its use as hay reduced the necessity for the purchase of protein feeds. Many experiments were carried out this year to determine the adaptability and usefulness of this plant in the various sections of the State; the season was, however, unusually unfavorable in many respects for the success of these experiments—the heavy rains stimulating a very rapid growth of weeds and the scalding of the young alfalfa plants.

The investigations concerning the composition of milk of dairy herds have been continued, and the data obtained fully confirm the conclusions already reached, that it is possible to control, within reasonable limits, the composition of milk, and thus to guarantee a uniform product to the consumer. The study of the economics of the retail dairy business has also been continued.

An addition to the barn at the College Farm was built through the generosity of the Trustees, and in its erection an attempt was made

to have incorporated such features as are now believed to be essential in the housing of dairy stock for the purpose of producing sanitary milk. A full description and outline plans are contained in the main body of the report. A small silo has also been erected by the Station to study the question of the comparative value of soiling and of summer silage; this has been partly filled with corn and cow peas for future feeding experiments. This is a distinct and important addition to the working equipment of the Station. The farm, aside from its usefulness in providing for the carrying out of experiments, is a valuable adjunct to the Station in furnishing an object-lesson in modern methods of farm management. The increased number of visitors from all parts of the State express themselves as much benefited by what they see and hear. The application of the principles of scientific farming are apparent here, and the results are uniformly in favor of the adoption of the practice recommended, *i. e.*, that the proper handling and use of farm manures, the growing of green manure crops, the use of good seed, and the application of business principles to all the details of the work result in making farming profitable. For the year ending April 1st, 1901, there was produced an average of 8.1 tons of forage for each acre under cultivation.

BIOLOGY.

In the Biological Department the work has followed the same lines as last year, viz.: Bovine tuberculosis, dairy bacteriology and oyster culture.

Under the first head, an extended series of observations of cows' temperatures has been taken, with unusual care, to ascertain as *accurately as possible the relative effect of external conditions—particularly* air temperature fluctuations—upon the "temperature curve" of cattle. These data are published in the present report.

Under the second head, the Bulletin No. 152, "Domestic Pasteurizing Methods and the Care of Milk in the Home," was issued early in the summer. This is a popular exposition of the results of the experiments and household experience of the biologist in caring for milk during hot weather, and includes a description of the methods of using milk in infant feeding.

The principal line of work of the biologist has been the subject of "scientific oyster propagation," a special act having been passed by the last Legislature, making a small appropriation for "establish-

ing and maintaining" one or more oyster experiment stations, under the direction of the Agricultural College Experiment Station.

Such a station was established, and maintained near Tuckerton, during the oyster-breeding season, from June 20th to August 30th. Careful studies have been made of the eggs of oysters, which are so small that they are individually about invisible to the naked eye. Oysters have been raised from the "spat stage" to the "seed stage" in tanks and other artificial surroundings, showing that the conditions in such environments were favorable to life and growth.

As a result of the season's work, the biologist is convinced of the erroneousness of the current beliefs, that if artificially propagated oyster spawn were given the proper food and environment, it will live and mature; and that if we only knew how to properly care for such spawn, the problem of artificial oyster propagation would have been solved.

The real trouble, however, seems to be that we do not yet know how to select eggs of the proper ripeness and vigor, nor how to fertilize them with the best sperms. Therefore, the investigations were mainly directed towards the careful study of oyster eggs, and the results are illustrated by means of several plates accompanying this report.

BOTANY.

The work in the Botanical Department for the year has been largely upon the Experiment Area at the College Farm, supplemented with laboratory study, and investigations in various parts of the State.

Attention has been given to the breeding of sweet corn, beans, lima beans, tomatoes, egg-plants, cucumbers, salsify, squashes, etc. The hope of combining a white and black sort of sweet corn so as to produce a new pink variety is beginning to be realized in that several ears with all the grains of the desired color have been obtained the present season. Out of the same line of work, by careful selection, it is hoped to obtain a variety with unusual productiveness.

The combination of two standard sorts of bush lima beans has been effected, and the cross shows a union of the good qualities of the parents. It still remains to fix the characteristics in this new variety when it will be ready for distribution.

The same is true of the new egg-plant that is superior to both the parents, and with an acceptable shape, high quality and productive, vigorous plants, it may prove a valuable acquisition to our truck

farmers. There is a demand for the seed, but it is withheld, as more time is required to fix the strain.

Some superior forms of cucumbers have come from breeding, and it is hoped that shortly the Station will have something in this line to offer its constituents.

The end in view in the crossing of tomatoes, namely, a more upright and vigorous plant with the amount of seed in the fruit greatly reduced, is being approached, and tomatoes absolutely seedless have been obtained. The work of fixing the desired qualities here may require more time than with the other kinds of plants above named.

A hybrid between two species of salsify has shown remarkable variations in some directions, but sufficient time has not elapsed for a test of the quality of the roots.

In connection with the above tests in breeding some interesting facts have become evident that will help in future work along the same lines.

Some time has been given to the study of such weeds as broom-rape and dodder, and the latter is a subject for study in the greenhouse. Tests have also been made under glass to determine the effect of conditions upon sex and sex organs in plants. For this flax and buckwheat have been employed. Albinism in sweet corn was under examination through the winter, and it was found not to be due to any condition of germination, but is in the seed itself and perhaps the result of some enfeebled growth. Some spraying experiments in the greenhouse point to kerosene emulsion as a suitable remedy for the powdery mildew of hot-house roses and many other plants grown under glass. This line of study is to be hopefully continued.

Many plants have been determined from week to week, and occasional samples of suspected commercial seeds examined for weed seeds.

One bulletin has been issued since the last annual report, namely, No. 151, "Bean Diseases and Their Remedies," with four plates, nine figures and twenty-eight pages.

ENTOMOLOGY.

In the department of insects one of the main lines of investigation has been a study of the mosquito problem as it exists in the State at the present time. The subject is too large for any one person to cover in any one year, and all that was attempted was to ascertain, *first*, the distribution of the species responsible for the spread of malarial diseases; *second*, the determination of the most common species and their distribution in the State; *third*, the general methods that might be employed to check or control the insects; and *fourth*, the part that the individual, municipality and State respectively should assume in the effort to effect a permanent mitigation of a pest which, directly and indirectly, causes a loss of many thousands of dollars annually to our citizens and lessens enormously the value of much of the coast and other lands of the State. The investigation has reached a point where it requires material assistance to complete the work and promises results that will do away with from 75 per cent. to 90 per cent. of the troublesome forms in the State.

The life history of the katydid that annually destroys thousands of bushels of cranberries has been completed and the egg-laying habits have been ascertained. It will now be possible for the growers to control the insect and practically avoid injury by simple and inexpensive methods.

Studies on scale insects have been continued and the life history of the form that has of late years injured blackberry and raspberry canes has been completed.

Work in the Experiment Orchard has been continued and a number of insecticides have been tested to ascertain their range of usefulness against insects and their effects on plant-life.

The work done with crude petroleum to check the spread and injury done by the San José or pernicious scale has been followed and the experience gained will be iucorporated in the annual report.

An interesting line of work was the introduction into the State of a Chinese species of *Mantid*, a predatory insect which, it is hoped, will prove useful in checking the spread of certain injurious forms. It appears now tbat the work will prove successful so far as the introduction of tbe insect is concerned; whether it will prove as beneficial as is hoped, remains to be seen.

A number of less important investigations were carried on as the character of the complaints received during the season made it necessary. In all respects the season has been busy as well as profitable.

Two bulletins were issued from the Department since the last report: No. 147, dealing with the "Angoumois Grain Moth," and No. 149, dealing with "Two Strawberry Pests."

As in the past, the Station officers have kept in close contact with the farmers throughout the State, by attending the various meetings of the county boards of agriculture, of farmers' institutes, by the issuing of special information bulletins on various subjects, and by direct correspondence with the farmers. The Station, in addition to its function as an institution for scientific investigation, is a bureau of information on all subjects relating to the farm.

During the year many additions of valuable books of reference have been made to the library, besides the binding of reports and bulletins of other Stations; it is also well supplied with all of the leading journals, bearing upon the various lines of scientific work connected with the institution, together with the leading agricultural and stock papers.

The equipment of the various departments has also been materially enlarged, particularly in the chemical and biological departments, and the working facilities of all well kept up.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

FERTILIZERS.

I.

THE MARKET PRICES OF FERTILIZERS.

For a number of years past, this Station has published a record of the annual sales of fertilizers in the State. Each year of late the manufacturers have shown more reticence about supplying the data covering their output, and for this reason it is thougbt best this year to omit the statistical part of this report.

The records of preceding years have shown that the farmers of this State have paid on an average about $1,200,000 annually for complete fertilizers. It is, therefore, a matter of importance to ascertain the principal conditions which influence the selling price of these materials.

Complete fertilizers are made by mixing a number of crude products or raw materials, each of which contains one or more of the following elements of plant-food, viz., nitrogen, phosphoric acid and potash. Efforts have been made, therefore, to secure—

The average wholesale prices of nitrogen, phosphoric acid and potash.
The average retail prices of nitrogen, phosphoric acid and potash.
The advance in prices between the wholesale and retail markets.

The wholesale prices of crude products, or raw materials, are quoted every Monday in the well-known trade journal, *The Oil, Paint and Drug Reporter*. These prices have been tabulated for the entire year, and have then been recalculated upon the basis of the following analyses, in order to express the results as prices of actual plant-food, which is the form adopted by the Experiment Stations of this country.

Nitrate of Soda	16	per cent.	Nitrogen.
Sulfate of Ammonia	20½	"	"
Dried Blood	12½	"	"
Acid Phosphate	12	"	Available Phosphoric Acid.
High-Grade Sulfate of Potash	50	"	Potash.
Double Sulfate of Potash and Magnesia	25	"	"
Muriate of Potash	50	"	"
Kainit	12½	"	"

The retail prices were calculated from the analyses of those samples of raw materials published in the report of 1900, which were taken from goods in the hands of farmers and which had been bought for cash direct from the manufacturers of complete fertilizers.

The price of nitrate of soda showed a considerable fluctuation, particularly from March 1st to July 1st, varying from 10.4 to 13.7 cents per pound. The average price, 11.6 cents, is much higher than that of last year, and higher than any year since 1894. Sulfate of ammonia has been quite constant in price during the year, being slightly lower than in 1899. Dried blood has shown the greatest increase in price of any of the raw materials, reaching as high as 15.5 cents in February, with an average for the year of 14 cents. Acid phosphate and the potash salts showed little fluctuation during the year, and the average prices differ little from those of previous years.

Wholesale Prices in New York, per Pound, of Plant Food.

MONTHS.	WHOLESALE COST OF NITROGEN IN FORM OF—						WHOLESALE COST OF PHOSPHORIC ACID IN FORM OF—		WHOLESALE COST OF POTASH IN FORM OF—							
	NITRATE OF SODA.		SULFATE OF AMMONIA.		DRIED BLOOD.		ACID PHOSPHATE		KAINIT.		MURIATE OF POTASH.		DOUBLE SULFATE OF POTASH AND MAGNESIA.		HIGH-GRADE SULFATE OF POTASH.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	11.8	11.5	14.6	14.4	13.6	13.3	3.1	3.0	4.1	3.5	3.7	3.6	4.2	4.1	4.1	4.0
February	12.5	12.1	14.9	14.6	15.5	15.1	3.1	3.0	3.9	3.5	3.7	3.6	4.2	4.1	4.1	4.0
March	13.7	13.1	15.2	15.1	15.2	15.1	3.3	3.1	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
April	13.3	12.8	14.9	14.6	15.2	14.9	3.3	3.1	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
May	11.8	11.1	14.3	14.1	14.1	13.8	3.3	3.1	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
June	10.5	10.4	14.1	13.9	13.0	12.5	3.3	3.1	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
July	10.9	10.8	13.8	13.6	12.9	12.4	3.3	3.1	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
August	11.2	10.9	14.0	13.9	13.8	13.7	3.4	3.3	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
September	11.2	11.0	13.7	13.6	13.6	13.6	3.4	3.3	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
October	11.3	11.1	13.8	13.6	14.1	14.1	3.4	3.3	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
November	11.4	11.3	13.7	13.6	14.4	14.4	3.3	3.2	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
December	11.5	11.3	13.8	13.7	14.1	14.0	3.3	3.0	3.8	3.6	3.7	3.7	4.3	4.2	4.2	4.1
Average for 1900	**11.6**		**14.2**		**14.0**		**3.2**		**3.7**		**3.7**		**4.2**		**4.1**	
Average for 1899	**10.4**		**14.4**		**11.1**		**3.3**		**3.7**		**3.6**		**4.2**		**4.0**	
Average for 1898	**11.0**		**12.4**		**10.5**		**2.8**		**3.6**		**3.7**		**4.4**		**4.1**	

AVERAGE RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH IN CRUDE MATERIALS.

With few exceptions, the samples of raw materials analyzed in 1900 were taken from goods in the hands of farmers, and had been bought for cash direct from the manufacturers of complete fertilizers. After an analysis of the samples, therefore, it was not difficult to calculate the retail prices per pound of the various forms of nitrogen, phosphoric acid and potash used in this trade.

The tables on pages 37 to 39, in the report of 1900, furnish in detail the information gained by this work, and afford data also for the following summary. For comparison, results secured in a similar manner in 1894, 1895, 1896, 1897, 1898 and 1899, are republished:

COST PER POUND OF—	1894.	1895.	1896.	1897.	1898.	1899.	1900.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.
Nitrogen from Nitrate of Soda	14.3	13.4	12.7	12.9	12.3	12.2	12.9
" " Sulfate of Ammonia	18.8	....	13.8	11.8	14.0	14.3	15.8
" " Dried Blood	16.7	13.8	11.9	11.3	11.5	12.9	14.0
" " Dried Fish	17.5	16.4	13.7	12.8	11.5	13.3	13.7
" " Ammonite	....	14.9	....	....	....	13.5	14.4
Soluble Phosphoric Acid from Bone Black	6.5	5.8	5.6	5.3	....	....	....
" " " " S. C. Rock	4.7	4.3	4.5	3.6	3.3	3.7	4.1
Reverted " " " Bone Black	6.5	5.8	5.6	5.3	....	....	....
" " " " S. C. Rock	4.7	4.3	4.5	3.6	3.3	3.7	4.1
Potash from High-Grade Sulfate	4.9	4.5	4.8	4.9	4.0	5.3	4.5
" " Double Sulfate of Potash and Magnesia	....	....	4.5	5.2	4.3	....	....
" " Kainit	4.8	4.7	4.7	4.3	4.0	4.5	3.4
" " Muriate	4.1	3.9	4.0	4.1	3.8	4.0	4.1

These averages are the *manufacturers' retail cash prices for the nitrogen, phosphoric acid and potash in the crude stock from which complete fertilizers are made.*

COMPARISON BETWEEN THE AVERAGE WHOLESALE AND RETAIL PRICES OF NITROGEN, PHOSPHORIC ACID AND POTASH.

The conclusions reached in regard to the wholesale and retail prices are here tabulated. They represent the manufacturers' *wholesale and retail prices* for plant-food *in its best forms.* The percentages by which the retail prices exceed the wholesale have been taken as the basis of the comparison.

	MANUFACTURERS' AVERAGES.				AVERAGE PERCENTAGE BY WHICH THE RETAIL PRICES EXCEED THE WHOLESALE.		
	Wholesale prices for 1899.	Retail prices for 1899.	Wholesale prices for 1900.	Retail prices for 1900.	1898.	1899.	1900.
	cts.	cts.	cts.	cts.			
Nitrogen from Nitrate of Soda	10.4	12.2	11.6	12.9	11.8	17.3	11.2
" " Sulfate of Ammonia	14.4	14.3	14.2	15.8	12.9	*0.7	11.3
" " Dried Blood	11.1	12.9	14.0	14.0	9.5	16.2	....
" " Dried Fish	....	13.3	....	13.7	....	....	....
" " Ammonite	....	13.5	....	14.4	....	....	....
Soluble Phosphoric Acid from Bone Black	....	....	....	....	....	....	....
" " " " S. C. Rock	3.3	3.7	3.2	4.1	17.9	12.1	28.1
Reverted " " " Bone Black	....	....	....	....	....	....	....
" " " " S. C. Rock	3.3	3.7	3.2	4.1	17.9	12.1	28.1
Potash from High-Grade Sulfate	4.0	5.3	4.1	4.8	*2.5	32.5	17.1
" " Double Sulfate of Potash and Magnesia	4.2	....	4.2	....	*2.8	....	....
" " Kainit	3.7	4.5	3.7	3.4	11.1	21.6	*8.8
" " Muriate	3.6	4.0	3.7	4.1	2.7	11.1	10.8

*Wholesale price exceeds retail.

II.

THE CHEMICAL EXAMINATION OF FERTILIZERS.

1. *Introduction.*
2. *The trade values of fertilizing idgredients for 1901, and the examination of the standard materials supplying them.*
3. *The examination and valuation of manufactured brands, home mixtures, special compounds and sundry materials.*

1.

INTRODUCTION.

The Fertilizer Law.

The fertilizer law of this State is as follows :

An act to regulate the manufacture and sale of fertilizers [approved March 24th, 1874, and amended March 27th, 1878.]

1. That every commercial fertilizer which shall he offered for sale in this State shall be accompanied by an analysis, stating the percentage therein of ammonia, or its equivalent of nitrogen ; of potash, in any form or combination, soluble in distilled water ; and of phosphoric acid in any form or combination ; the portion of phosphoric acid soluble in distilled water ; that portion soluble in a neutral solution of citrate of ammonia at a temperature not exceeding one hundred degrees Fahrenheit ; and that portion of phosphoric acid not soluble in either of the above-named fluids, shall each be determined separately ; and the material from which the phosphoric acid is obtained shall also be stated ; a legible statement of such analysis shall accompany all packages or lots of over one hundred pounds sold, offered or exposed for sale.

5. That any person selling, offering or exposing for sale any commercial fertilizer without the analysis required by the first section of this act, or with an analysis stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, shall forfeit fifty dollars for the first offense and one hundred dollars for each subsequent offense ; *provided, further,* that the provisions of this section shall not apply to any manure sold at a price not exceeding one-half a cent per pound, nor to any imported guanos.

From the Station's standpoint this involves :

1. *The securing of samples.*
2. *The selection of the samples for examination.*
3. *The chemical analysis.*

1. The Securing of Samples.

In order that the inspection of fertilizers may be of value to the State, it is necessary that the samples analysed should be beyond question as to having been properly taken and carefully preserved, so as to fairly and justly represent the bulk of the material from which they are drawn. Success in this particular depends as much on experience, is often as difficult to attain and is quite as important as the subsequent chemical work in the laboratory. For this reason the samples analysed under the act are with a few exceptions taken by duly-authorized Inspectors, many of whom have been doing this work for the Station for years. These gentlemen are farmers of the highest standing in the community, and are willing to assume this duty solely because it is regarded as a matter of vital interest to the farming public.

The names of those who have represented the Station during the past season are as follows :

INSPECTORS FOR 1901.

CHAS. KRAUS	Egg Harbor City	Atlantic county.
J. HECK	Westwood	Bergen county.
H. I. BUDD	Mount Holly	Burlington county.
SAMUEL WOOD	Haddonfield	Camden county.
J. H. RICHARDSON	Rio Grande	Cape May county.
H. O. NEWCOMB	Cedarville	Cumberland county.
J. B. WARD	Lyons Farms	Essex county.
J. C. GRISCOM	Woodbury	Gloucester county.
AUGUSTUS DILTS	Flemington	Hunterdon county.
J. M. DALRYMPLE	Hopewell	Mercer county.
W. T. WOERNER	New Brunswick	Middlesex county.
HENRY D. HANCE	Freehold	Monmouth county.
J. J. MITCHELL	Troy Hills	Morris county.
WOODNUTT PETTIT	Salem	Salem county.
H. S. VAN NUYS	Millstone	Middlesex county.
D. N. WARBASSE	Newton	Sussex county.
F. E. WOODRUFF	Cranford	Union county.
W. O. WARD	Hainesburg	Warren county.

At the beginning of the season each Inspector is furnished with a sampling tube, blanks for describing samples, bottle labels, etc., together with printed instructions regarding their use. Each Inspector is requested to secure a sample of every brand of commerical

2. The Selections of the Samples for Examination.

As fast as the samples are secured they are shipped to the Station. Many duplicates are received, but all are given a distinguishing number and properly stored, and an entry is made for each in an appropriate book, showing at a glance the name of the brand and the place or places where it has been found. From among the duplicates of each brand a selection is made at random, but with the aim in view of causing the analyses representing any one firm to be of samples drawn from as many different counties of the State as possible.

This method of selection, it is believed, is more likely to cause the analyses to demonstrate the general quality of a manufacturer's product and to disarm any suspicion or insinuation on the part of rival dealers that the goods were specially prepared to be sampled, which might arise if the sample analysed was taken upon request.

Under certain conditions, however, this rule is not strictly adhered to. When purchases are to be paid for according to the Station's analysis and their magnitude warrants, or when the analysis will add to the information of the Station, or will demonstrate a possible development of waste products into cheap sources of plant-food, or in other ways is of general interest, the Station performs the work free of charge; but in all cases it requires that full and sufficient information concerning the sample be furnished, in order that there may be no unnecessary duplication of work, and when accomplished, the analysis may be of service to the general public.

The following is a list of those business houses the analyses of whose goods are published in this report:

Manufacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen........ Lawrence Station, N. J.
Allentown Manufacturing Co........ Allentown, Pa.
American Agricultural Chemical Co........ No. 26 Broadway, New York City.
H. J. Baker & Bro. Branch........ 93 William St., New York City.
Bradley Branch........ New York City.
Chemical Co. of Canton Branch........ 32 S. Charles St., Baltimore, Md.
Chicopee Guano Co. Branch........ 88 Wall St., New York City.
Great Eastern Branch........ Rutland, Vt.
Pacific Guano Branch........ New York City.
Packers' Union Branch........ 150 Nassau St., New York City.
Moro Phillips Branch........ 710 The Bourse, Philadelphia, Pa.
Preston Branch........ Greenpoint, L. I., N. Y.

The Quinnipiac Co. Branch .... New York City.
Read Branch .... 16 Exchange Place, New York City.
Sharpless & Carpenter Branch .... 710 The Bourse, Philadelphia, Pa.
Susquehanna Branch .... Baltimore, Md.
Tygert-Allen Branch .... 2 Chestnut St, Philadelphia, Pa.
Williams & Clark Branch .... 27 William St., New York City.
Armour Fertilizer Works .... 205 La Salle St., Chicago, Ill.
Warren Atkinson .... Mullica Hill, N. J.
James H. Baird .... Marlboro, N. J.
Baugh & Sons Co .... 20 S. Delaware Ave., Philadelphia, Pa.
The Berg Co .... Russell and Bath Sts., Philadelphia, Pa.
A. Berg Glue Co .... Ontario St., Philadelphia, Pa.
Berger Bros .... Easton, Pa.
Bowker Fertilizer Co .... No. 43 Chatham St., Boston, Mass.
Bradley & Green Fertilizer Co .... 9th St. and Girard Ave., Philadelphia, Pa.
W. M. Brown .... Cedarville, N. J.
E. Frank Coe Co .... 133 Front St., New York City.
John S. Collins & Son .... Moorestown, N. J.
Collins & Pancoast .... Merchantville, N. J.
Peter Cooper's Glue Factory .... 13 Burling Slip, New York City.
I. S. Curtis .... Frenchtown, N. J
Davis, Colson & Co .... Woodstown, N. J.
B. F. Demarris & Son .... *Cedarville, N. J.*
J. H. Denise .... Freehold, N. J.
J. Y. Dilatush .... Robbinsville, N. J.
H. W. Doughten .... Moorestown, N. J.
Runyon Field .... Bound Brook, N. J.
J. C. Fifield Sons & Co. .... Bakersville, N. J.
L. Fischer .... Belford, N. J.
Fithian & Pennell .... Bridgeton, N. J.
Geo. B. Forrester .... 159 Front St., New York City.
W. O. Garrison .... Bridgeton, N. J.
J. C. Griscom .... Woodbury, N. J.
F. E. Hancock .... Walkerton, Ontario, Canada.
Wyckoff Hendrickson .... Allentown, N. J.
S. M. Hess & Bro .... Reading, Pa.
Ira Hill .... Copper Hill, N. J.
Hill & Co .... Flemington, N. J.
Hires & Co .... Quinton, N. J.
International Seed Co .... Rochester, N. Y.
The Keystone Chemical Co .... Camden, N. J.
F. R. Lalor .... Dunnville, Ont., Can.
Lister's Agricultural Chemical Works .... Newark, N. J.
The Mapes F. & P. Guano Co .... 143 Liberty St., New York City.
Frank Maul .... Greenwich, N. J.
Hugh McAnany .... 19 N. Juniper St., Philadelphia, Pa.
John E. Minch .... Bridgeton, N. J.
Mixner & Mickel .... Bridgeton, N. J.
Monmouth Chemical Works .... Shrewsbury, N. J.

G. L. Monroe .... Oswego, N. Y.
Albert Nelson & Co .... Allentown, N. J.
Wm. C. Newport & Co .... Willow Grove, Pa.
James E Otis .... Tuckerton, N. J.
S. L. Pancoast .... Mullica Hill, N. J.
Peterson & Smith .... Woodstown, N. J.
Philadelphia Morocco Co .... Philadelphia, Pa.
Enos Richmond .... Elmer, N. J.
Edward Rigg, Jr .... Burlington, N. J.
M. F. Riley .... Elmer, N. J.
James Ross .... Trenton, N. J.
Ruckman Bros .... New Brunswick, N. J.
Russell Agricultural Chemical Co .... Newark, N. J.
Saul & Johnson .... Erma, N. J.
Sharpless & Bro .... Camden, N. J.
M. L. Shoemaker & Co .... Delaware Ave. and Venango St., Philadelphia, Pa.
Lester Shurts .... Neshanic, N. J.
L. W. Sickler .... Glassboro, N. J.
Rufus W Smith .... Elmer, N. J.
Somerset Chemical Co .... Bound Brook, N. J.
Stevens Bros .... Cedarville, N. J.
Swift & Co .... Chicago, Ill.
Henry Taylor .... Vineland, N. J.
The Taylor Provision Co .... Trenton, N. J.
I. P. Thomas & Son Co. .... 2 S. Delaware Ave., Philadelphia, Pa.
Trenton Bone Fertilizer Co .... Trenton, N. J.
The J E. Tygert Co .... 42 S. Delaware Ave, Philadelphia, Pa.
The Tyler-Hall Chemical Co .... Readburn, N. Y.
Vineland Grain Co .... Vineland, N. J.
Emil Wahl Mfg. Co .... No. 3870 Pulaski Ave., Nicetown, Philadelphia, Pa.
Warren Fertilizer Works .... Belvidere, N. J.
Geo. M. Wells .... Moorestown, N. J.
West Jersey Marl and Transportation Co .... Woodbury, N. J.
W. E. Whann .... William Penn, Pa.
Winterbottom, Carter & Co .... Egg Harbor City, N. J.

3. The Chemical Analysis.

The chemical analysis includes a test for the three forms of nitrogen, viz., as nitrates, as ammonia salts and as organic matter, and a quantitative determination of each when found. Likewise the total phosphoric acid is determined, and also that portion of it which is soluble in water, and that soluble and insoluble in ammonium citrate solution.

Potash and chlorin determinations are also made, and when potash is found in excess of that needed to form muriate of potash with the chlorin present, it is credited to the manufacturer as being in the form of sulfate. Brands in which the latter has been the case are designated in the tables by an asterisk in the potash column.

This complete examination is of value in furnishing information regarding the kind and quality of the materials used in mixed fertilizers.

The section of the fertilizer law published in the introduction to this chapter, indicates that in this State certain analyses must be made according to prescribed methods; in the others the methods to be used are left to the judgment of the officers of the Station, and are those recommended by the Association of Official Agricultural Chemists.

2.

THE TRADE VALUE OF FERTILIZING INGREDIENTS FOR 1901, AND THE EXAMINATION OF THE STANDARD MATERIALS SUPPLYING THEM.

In most States in which a fertilizer control is exercised it is customary to estimate and affix a commercial valuation to the various materials analysed. This estimated commercial value, it must be clearly understood, is separate and distinct from the agricultural value, the latter depending upon the character and form of the material with reference to its availability and the needs and value of the crop for which it is to be applied. The former, on the other hand, is determined by market and trade conditions, such as supply and demand, the cost of production, the methods of manipulations required, etc. It is derived by applying to the various forms of plant-food ingredients, as shown by analysis, the values previously determined upon for them. These values are fixed from year to year, and are altered according to the cost of the standard materials containing these forms of plant-food, as shown in market reports and actual transactions.

It is not asserted that this system shows absolutely the commercial value of each brand at the time that the sales were made, but only the relative commercial value of the different brands. It is not intended to be a guide to the agricultural value, even relatively, and therefore cannot mislead in this direction. It is a guide to the charges for mixing, handling and selling plant-food contained in the different brands as compared with other brands. Any system of comparison of brands must leave a great deal to the judgment of the purchaser; he must determine for himself whether he would rather that his phosphoric acid, for example, were more or less soluble, that the nitrogen should be derived from the more quickly-acting nitrate, or the more lasting organic forms, or whether for his purpose the muriate is just as good as the more expensive sulfate of potash. These conditions are indicated by the analysis which accompanies

the valuation, and the latter is not to be used in total disregard of the former. With these points clearly understood, a comparison of commercial values cannot be regarded as discriminating against specific manufacturers or particular brands.

The wholesale prices per pound of plant-food prevailing in New York during the six months immediately preceding March 1st last, were for nitrogen in nitrate of soda, 11.3 cents; in sulfate of ammonia, 13.7 cents, and in high-grade dried blood, 14.1 cents; for available phosphoric acid in acid phosphate, 3.2 cents, and for actual potash in muriate of potash, 3.7; in kainit, 3.7 cents; in double sulfate of potash and magnesia, 4.3 cents, and in high-grade sulfate of potash, 4.2 cents. A comparison of these figures with those of last year will show that there have been advances in the market prices of acid phosphate and of the ammoniates, or nitrogen-furnishing materials, sulfate of ammonia excepted; these advances have, however, been taken into account in arranging the schedule.

From this as a basis, therefore, the following schedule of trade values was arranged at a meeting of Station Directors and Chemists for use in Connecticut, Massachusetts, New York, Rhode Island, Vermont and New Jersey during the season of 1901:

Schedule of Trade Values Adopted by Experiment Stations for 1901.

	Cents per pound.
Nitrogen in Nitrates	14.0
" " Ammonia Salts	16.5
Organic Nitrogen in dried and fine ground fish, meat and blood, and in mixed fertilizers	16.0
" " " fine-ground bone and tankage	16.0
" " " coarse bone and tankage	12.0
Phosphoric Acid, soluble in water	5.0
" " " " ammonium citrate*	5.0
" " insoluble in fine bone and tankage	4.0
" " " " coarse bone and tankage	3.0
" " " " mixed fertilizers	2.0
" " " " fine-ground fish, cotton-seed meal, castor pomace and wood ashes	4.0
Potash as Muriate	4.25
" " Sulfate and in forms free from muriates (or chlorids)	5.0

*The solubility of phosphates, in ammonium citrate solutions, is seriously affected by heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90) provides that in this determination the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has been adopted. The higher the temperature the larger will be the percentage of phosphoric acid dissolved by ammonium citrate solutions, and the larger the amount of so-called "reverted" phosphoric acid in a ton of superphosphate at a given price the lower will be the price per pound of said acid. Consequently the Station valuation of phosphoric acid, soluble in ammonium citrate, has been fixed at *four and one-half* cents per sound for Connecticut, Massachusetts, New York, Rhode Island and Vermont, and at *five* cents per pound for New Jersey.

Valuation of Fertilizing Ingredients in Fine-Ground Feeds.

Organic Nitrogen	14.5
Phosphoric Acid	4.0
Potash	5.0

The results of analysis of 59 samples of standard raw materials appear in tabulated form upon subsequent pages. They include samples of nitrate of soda, sulfate of ammonia, dried blood and ammonite, dried and ground fish, tankage, ground bone, hair manure, South Carolina rock superphosphates, muriate and sulfate of potash and kainit. The samples of nitrate of soda and sulfate of ammonia are of good quality. The dried blood and dried and ground fish, show considerable variability, as is usually the case, and the samples of the plain superphosphates and of the various forms of potash were of good quality, almost without exception.

Average Cost Per Pound of Plant-Food Constituents.

In connection with the analyses is given the cost per pound of the essential fertilizing ingredient which it supplies. This is derived by dividing the cost per ton of the material by the number of pounds of that ingredient in a ton, as determined by analysis. The samples represent actual transactions of farmers' clubs, and of individuals. Therefore, if the cost per pound of the nitrogen, phosphoric acid or potash in these samples (with the exception of a few, which were purchased under particularly unfavorable circumstances) be averaged, the result may be fairly assumed to represent the average manufacturers' actual retail price at factory for tne same, and admit[s] of a comparison with the Station's price, which is intended to represent the retail cash cost per pound of the fertilizing ingredients contained in the raw materials before they have been mixed to form the various commercial brands.

COMPARISON BETWEEN WHOLESALE PRICES AND MANUFACTURERS' AVERAGE RETAIL PRICES OF PLANT-FOOD IN FERTILIZER SUPPLIES AS DERIVED FROM ACTUAL TRANSACTIONS, AND STATIONS' SCHEDULE FOR 1901.

AVERAGE COST PER POUND OF—	Wholesale, September, 1900, to March, 1901.	Manufacturers' average retail prices.	Stations' schedule of prices.
	cts.	cts.	cts.
Nitrogen from Nitrate of Soda	11.3	13.2	14.0
" " Sulfate of Ammonia	13.7	16 5	16.5
" " Dried Blood	14 1	15.4	16.0
" " Dried and Ground Fish	......	16.7	16.0
Phosphoric Acid, available	3.2	3.9	5.0
Potash from Muriate	3.7	4.2	4.25
" " Kainit	3.7	4.0	4.25
" " High-Grade Sulfate	4.2	4.4	5.0

A study of the foregoing table shows that the manufacturers' retail prices for plant-food are, on the average, 14.3 per cent. greater than the wholesale, and the prices in the Station's schedule, on the average, are 3.4 per cent. greater than these, which is a total advance of Station's prices over wholesale prices, on the average, of 18 per cent. The application of this schedule to the plant-food in mixed goods is, therefore, perfectly fair to the manufacturers in showing the relative commercial value of the different brands.

The Purchase of Fertilizer Ingredients.

The experience of the Station in the past, and a study of the analyses of the raw materials, leads to the development of some observations and suggestions in relation to the purchase of these materials. The absence of guarantee in many instances, and the variation from the same in others, gives rise to a belief that they may prove useful.

Nitrate of Soda.—This is a material quite uniform in composition, an inferior sample being exceptional. Such a sample was received in 1898 for the first time since the organization of the Station. The samples examined this year range from 15.62 per cent. to 15.98 per cent. of nitrogen, or from 95 to 97 per cent. of purity. Samples are occasionally slightly below the average, but, nevertheless, it may be said that, in general, it is safe to purchase this material without especial chemical examination, although, of course, it, as well as every other material, should be accompanied by a guarantee.

Attention, then, need be paid simply to obtaining it at the lowest price possible. The cost of nitrate of soda this year ranges from $40 to $43 per ton, a variation due not at all to the quality of the goods, but arising from the business methods and other conditions attending their purchase. These remarks apply in a similar manner to sulfate of ammonia, of which, however, comparatively little is used.

Animal Matter.—The animal fertilizing materials, such as dried blood, dried and ground fish, tankage, etc., are always more or less variable, and the samples of these materials this year are found to be no exception to the general rule. Thus the samples of blood vary in composition from 11.39 to 13.11 per cent. of nitrogen; those of dried and ground fish vary from 4.58 to 10.28 per cent. of nitrogen, and from 4.22 to 7.90 per cent. of phosphoric acid, with no relation between the amounts of nitrogen and phosphoric acid in the different samples, nor between them and the cost of the material. All these should be purchased, therefore, with a strict reference to guarantee and a comparison of the selling price therewith, or, better, on the "unit system" of purchase. Allowing 80 cents per unit for all the phosphoric acid they contained, and excluding those samples notably low grade, dried blood cost, on the average this year, $3.08, and dried and ground fish $3.34 per unit of nitrogen. This is respectively equivalent to $2.53 and $2.74 per unit of ammonia. Extreme prices were $3.47 per unit of nitrogen in dried blood, and $4.72 in dried and ground fish, equivalent to $2.85 and $3.87, respectively, per unit of ammonia. The Station rates this form of nitrogen, when found in complete fertilizers, at $3.20 per unit of nitrogen, equal to $2.62 per unit of ammonia.

Plain Superphosphates.—As usual, there is observed the same variation in composition and lack of relation between the composition and the price of the acid phosphates examined. They vary from 12.39 per cent. of "available," at $14, to 15.48 per cent., at $12 per ton, while the range in price is from $9.45 to $21.15. In the case of this material, also, the "unit system" will prove the more satisfactory method of purchase. The average cost per unit of "available" this year, excluding those samples of notably-deficient quality or excessive price, was 79 cents, ranging from 64 to 92 cents. The Station's allowance for this material in the valuation of mixed fertilizers is $1 per unit.

Sales of acid phosphate between large dealers and the smaller firms are made on the unit basis. The examination of the samples this year emphasizes the value of this system. It lies entirely with

the farmer to receive the advantage of this method of purchase, as no difficulty will be experienced in making contracts with the manufacturers on this basis.

Potash Salts.—The potash salts, while usually of good quality, nevertheless often show considerable differences in chemical composition. The guarantees accompanying them are, however, somewhat of a guide as to their purity, and possibly as much could be gained in their economical purchase by accepting the guarantees as correct, and endeavoring to secure a lower ton price, as by insisting on the analysis and allowing the price to take care of itself. Muriate of potash is often purchased on the basis of 80 per cent. purity. If the analysis shows a variation above or below 80 per cent., the purchaser pays for the excess or is remunerated for the deficiency at the same rate of purchase. This is similar to the "unit basis," is fair alike to the purchaser and the dealer, and requires a chemical analysis. The average price this year has been about $41 per ton for muriate of potash of 80 per cent. purity, or 83 cents per unit of actual potash. The Station values this in mixed goods at 85 cents per unit.

The Unit System of Purchase.

The unit system of purchase, referred to above, is the system upon which the manufacturers of mixed fertilizers buy these same materials for themselves. It is simply "buying upon analysis," since the purchaser pays a certain sum, previously agreed upon, for every per cent. of the essential kind of plant-food actually contained therein, and for fractions of a per cent. in proportion. With this agreement the goods are delivered, an analysis is made and the correct amount paid over. The purchaser therefore pays for what he gets, and gets what he pays for; the only part that is left for him to control is the rate or amount per unit to be paid. The average cost per unit of nitrogen this year has been $2.64 in nitrate of soda, $3.08 in dried blood and $3.34 in dried and ground fish; that of "available" phosphoric acid has been 79 cents, and that of potash has been 83 cents. The actual price to be paid depends, as do prices under any system, upon the business methods of the individual purchaser, together with various other conditions, such as the distance from market, the state of trade, the time of year, the size of order and the length of credit. *Those who study the conditions of the market, make up their orders early, and by combining with others purchase in considerable quantities and for cash, will undoubtedly secure better quotations than those who buy at the busiest season of the year, in small lots at a time, upon long credit and from the first-comer.*

FORMS OF NITROGEN.

Readily and Completely Soluble in Water.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Nitrate of Soda.		cts.	
1001	J. Fitzga, Somerville	15.98	12.52	$40 00
1029	A. H. Rogers, Hamilton Square	15.98	12.99	41 50
1085	C. C Hulsart, Matawan	15.77	13.32	42 00
1189	J. W. Pincus, Woodbine	15.62	13.44	42 00
1244	J. M. Dalrymple, Hopewell	15.73	13.67	43 00
	Average Cost per Pound		13.19	
	Sulfate of Ammonia.			
1538	C. Kraus, Egg Harbor City	19.81	16.48	65 30

FORMS OF NITROGEN INSOLUBLE IN WATER.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Percentage of Phosphoric Acid.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Dried Blood and Ammonite.			cts.	
0123	Wm. Dubon, Pittstown	12.85	0.48	15.28	$39 65
1086	C. C. Hulsart, Matawan	11.89	3.84	14.19	35 00
1190	J. W. Pincus, Woodbine	13.11	1.21	14.80	40 00
1539	C. Kraus, Egg Harbor City	12.83	1.38	17.23	45 30
	Average Cost per Pound			15.40	
	Dried and Ground Fish.				
0122	Wm. Dubon, Pittstown	5.14	5.61	*19.12	24 15
0136	M. C. Losen, Belford	10.28	6.54	12.05	30 00
0137	" "	9.38	7.90	15.82	36 00
1031	A. H. Rogers, Hamilton Square	8.39	7.25	16.21	33 00
1028	H. O. Newcomb, Cedarville	7.04	5.29	20.43	33 00
1040	" "	4.58	4.22	*23.60	25 00
1069	H. I. Budd, Mount Holly	8.12	7.46	16.03	32 00
1108	S. Wood, Haddonfield	8.39	6.77	15.84	32 00
1126	J. C. Griscom, Woodbury	8.26	7.54	17.49	35 00
1191	J. W. Pincus, Woodbine	8.34	6.94	15.14	30 00
1558	C. Kraus, Egg Harbor City	6.20	5.60	22.19	32 00
1582	" "	6.76	5.87	17.23	28 00
1555	" "	8.56	6.81	11.42	25 00
1542	" "	7.61	5.60	20.05	35 00
1556	" "	7.07	7.44	17.36	30 50
	Average Cost per Pound			16.71	

The phosphoric acid in every case has been valued at 4 cents per pound.
*Not included in the average.

FORMS OF NITROGEN INSOLUBLE IN WATER.

TANKAGE AND GROUND BONE.

Station Number.	FROM WHOM RECEIVED.	MECHANICAL ANALYSIS.		PERCENTAGE.		Cost of 2,000 lbs of Material.
		Finer than 1/50 inch.	Coarser than 1/50 inch.	Nitrogen.	Phosphoric Acid.	
1030	A. H. Rogers, Hamilton Square	.....	.....	6.53	12.32	$21 00
1192	J. W. Pincus, Woodbine	69	31	8.63	9.37	32 00
1450	D. N. Warbasse, Newton	82	18	5.00	18.06	26 00
1535	C. Kraus, Egg Harbor City	86	14	7.20	11.67	32 00
*1193	J. W. Pincus, Woodbine	60	40	2.20	28.42	21 50

* Ground Bone.

TANKAGE AND GROUND BONE.

Station Number.		COST OF NITROGEN PER LB. IN—		COST OF PHOSPHORIC ACID PER LB. IN—	
		Finer than 1/50 inch.	Coarser than 1/50 inch.	Finer than 1/50 inch.	Coarser than 1/50 inch.
		cts.	cts.	cts.	cts.
1192	Tankage	15.84	11.88	3.96	2.97
1450	"	14.29	10.72	3.57	2.68
1535	"	16.37	12.28	4.09	3.07
1193	Ground Bone	12.85	9.64	3.21	2.41
Average Cost per Pound		**14.84**	**11.13**	**3.71**	**2.78**

HAIR MANURE.

Station Number.	FROM WHOM RECEIVED.	Nitrogen.	Phosphoric Acid.	Potash.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
					cts.	
0129	B. F. Bishop, Rancocas	2.91	0.78	0.13	4.43	$3 90
1501	W. L. Moore, Swedesboro	8.96	0.67	0.07	2.00	5 00
Average Cost per Pound					**3.52**	

PLAIN SUPERPHOSPHATES.

Furnishing Soluble, Reverted and Insoluble Phosphoric Acid.

Station Number.	FROM WHOM RECEIVED.	PHOSPHORIC ACID. Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.	Cost of Available Phosphoric Acid per lb.	Cost of 2,000 lbs. of Material.
		%	%	%	%	cts.	
0120	Wm. Dubon, Pittstown	10.66	4.23	3.89	14.89	4.58	$18 65
0121	" " "	9.06	4.08	4.36	13.09	*8.08	21 15
1082	A. H. Rogers, Hamilton Square	8.76	4.93	3.55	13.69	4 20	11 50
1064	H. I. Budd, Mount Holly	12.50	2.58	1.81	15.08	4.14	12 50
1087	C C. Hulsart, Matawan	9.90	4.63	3.12	14.53	4.13	12 00
1149	H O Newcomb, Cedarville	13.34	2.14	0.89	15.48	3.87	12 00
1194	J. W. Pincus, Woodbine	12.02	2.13	2.09	14.15	3.36	9 50
1280	H. I. Budd, Mount Holly	9.14	4.44	2.27	13.68	4.05	11 00
1494	J. M. Dalrymple, Hopewell	11.20	3.58	1.13	14.78	*5.41	16 00
1506	G. W. Jessup, Moorestown	7.04	7.57	2.16	14.61	3.23	9 45
1587	C. Kraus, Egg Harbor City	9.20	5.63	2.15	14.88	3.86	11 50
1620	H. I. Budd, Mount Holly	5.34	7.05	4.08	12.39	*5.65	14 00
Average Cost per Pound						3.94	

* Not included in the average.

GERMAN POTASH SALTS.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Material.
	Muriate of Potash.		cts.	
1002	J. Fitzga, Somerville	52.36	3.82	$40 00
1033	A. H. Rogers, Hamilton Square	49.45	4.04	40 00
1088	C. C. Hulsart, Matawan	45.61	4.38	40 00
1195	*J. W. Pincus, Woodbine*	*50.44*	*3.87*	*39 00*
1460	A. Dilts, Flemington	50.47	4.21	42 50
1536	C. Kraus, Egg Harbor City	43.36	4.84	42 00
1540	" " "	53.33	3.98	42 40
1609	J. W. Opie, Three Bridges	49.69	4.20	41 70
1610	" "	48.86	....	....
	Average Cost per Pound	....	4.17	
	High Grade Sulfate of Potash.			
1196	J. W. Pincus, Woodbine	50.19	4.38	44 00
	Kainit.			
1348	W. O. Ward, Hainesburg	13.17	3.99	10 50

3.

THE EXAMINATION AND VALUATION OF MANUFACTURED BRANDS, HOME MIXTURES, SPECIAL COMPOUNDS AND MISCELLANEOUS PRODUCTS.

On the following pages are reported the analyses of

308	samples	of	Complete Fertilizers,
8	"	"	Home Mixtures,
18	"	"	Special Mixtures,
25	"	"	Ground Bone,
37	"	"	Miscellaneous Fertilizers and Sundry Materials, and
6	"	"	Complete Fertilizers excluded from the regular classification.

The main object of this work is to determine by chemical analysis whether the *actual* composition of each of the various manufactured products corresponds with its *guaranteed* composition, as required by law. By a comparison of the two it is shown whether the material fulfills the claims of the manufacturer, and how far the guarantee given is a guide as to the amounts of plant-food actually delivered to the consumer. In addition, the application of the Station's schedule of values, which has been adopted for the various kinds and forms of fertilizer constituents, and is published on a previous page, demonstrates comparatively whether the selling prices are justified, and the amounts by which the latter exceed the commercial values derived from the analyses represent the comparative charges of the different manufacturers for mixing and bagging their goods and effecting their sale.

This work is of direct value to the intelligent and experienced purchaser in furnishing definite information relative to the composition and value of the different brands to which his attention may be called, and is of indirect value to all purchasers in that it tends to reduce to a minimum the amount of worthless material offered for sale.

I. Complete Fertilizers.

The number of distinct commercial brands of complete fertilizers, the analyses of which are herewith reported, is eight more than last year. They are the product of 79 manufacturers, which is five less than last year. It is, therefore, evident that there is an increase in the number of brands per manufacturer; this increase amounts to about three brands for every ten manufacturers, so that the average representation this year is three and nine-tenths brands, instead of three and six-tenths brands per manufacturer, as found in 1900.

The average number of brands apiece is, therefore, about 4; there are 57 manufacturers represented by this number or less, 14 represented by from 5 to 8 (twice the average), 7 by from 9 to 12 (three times the average), and 1 by 16 brands, or four times the average.

The extent to which multiplication of brands is in some cases carried would seem to be in excess of that needed for a range of choice, especially in those cases when the differences, to all practical purposes, are in name only. Whether it is warranted by commercial reasons is another question, for it is undeniable that manufacturers supply, as a rule, only that which consumers demand. The inspectors who represent the Station in the different counties have instructions to send a sample of every distinct brand they can find in their locality or district. Samples from any one manufacturer, and indeed of the same brand, are thereby received in many cases from several different counties, and this representation may be taken as a measure of this demand. From the limited extent to which many brands are found distributed throughout the State, it is a question whether this demand is as great as might be supposed.

The Chemical Composition.

The complete fertilizers examined this year show a great diversity as regards composition, for they include the association of almost every amount of nitrogen from 0.72 to 9.12 per cent. (equal to from about nine-tenths per cent. to over 11 per cent. of ammonia), with almost every amount of phosphoric acid (available) from 2.97 to 12.88 per cent., and almost every amount of potash from 0.63 to 12.94 per cent. The complete examination which has been made of every brand discloses also that still further differences in composition exist, in that some manufacturers use nitrate or ammonia salts as a partial source of their nitrogen, and others use animal matter entirely, such as blood, or meat; some use sulfate of potash, and others the muriate or kainit; some supply a relatively larger amount of water-soluble phosphoric acid, and others of citrate-soluble, accompanied by more or less of insoluble phosphoric acid, of which the guarantee takes no account in many instances.

The proportion of the phosphoric acid which each of the various brands supplies can be readily learned from an inspection of the tables which follow. The average analysis of all the brands is 4.59 per cent. of water-soluble, 3.49 of citrate-soluble and 2.40 of insoluble (or acid soluble) phosphoric acid. The use of sulfate of potash as

the source of any considerable portion of the potash is indicated by an asterisk (*) in the potash column. There are among the 308 brands but 34 in which this is the case. Potash as sulfate receives a higher valuation than when in the form of muriate, since it costs somewhat more.

Nitrate of soda is used as a partial source of nitrogen in 189 of the brands, and salts of ammonia in 69, both being used in 40 of them. The nitrogen supplied as nitrate has ranged from nothing to 7.37 per cent., the average being 0.92 per cent., and that supplied as salts of ammonia has ranged from nothing to 1.89 per cent., the average being 0.60 per cent. These have been associated with varying amounts of organic nitrogen, ranging from 0.03 per cent. to 4.55 per cent., and averaging 1.62 per cent. When comparison of these figures is made with those given last year, they would seem to indicate an increase in the use of the water-soluble forms of nitrogen (particularly of nitrate of soda) in respect both to the amounts and to the number of brands in which they occur.

Brand Names.

In few instances is the composition or character of these materials, containing, as they do, almost every practicable amount and proportion of plant-food in the different forms—in few instances is it accurately designated by the brand name. Manufacturers by no means agree as to the true formula for a "Potato Manure," for instance; "Dissolved Bone Phosphate" does not necessarily imply that a trace of bone has been used in its manufacture; "Ammoniated Bone Superphosphate" may contain bone, but does not indicate that it often contains potash, and many brands could easily be mistaken (from a consideration of name alone) for pure bone meal.

The necessity may be seen, therefore, of the published statement of analysis or guaranteed composition of each brand, which is required by law, and the importance of a conformity of the actual composition with it.

Guarantees and Actual Composition.

Without exception, all of the brands examined this year have been accompanied by a guarantee, as the fertilizer law of New Jersey requires shall accompany all packages or lots of over one hundred pounds sold, offered or exposed for sale. Nevertheless, there has been a rather unusually large number of instances this year of

erroneous guarantees. On analysis certain brands have shown a composition which made the accompanying guarantee absurd. Requests on the part of the Station have elicited from the manufacturers the explanation that the goods have been put up in wrong bags, or drawn from the wrong heap or bin, or the regular bags have been used for goods which have been fortified according to the order of a certain customer, by the addition of more than usual of a certain ingredient. Occurrences of this sort are particularly annoying to the officers of the Station. It is the practice of the Station to analyze one sample of each brand, and publish this as representing, to the best of its knowledge, the composition of this brand wherever found; and while it would seem to be the manufacturer's own fault, if through wrong bagging a usually superior brand were published with an inferior analysis, on the other hand, it would be manifestly unfair to all others if an inferior brand, through the same means, were published as containing the superior analysis wherever found in the State. In the case of fortified brands, likewise, the analysis found does not represent the goods which the manufacturer advertises in his circulars. The special addition of extra material to a formula constitutes a change in the formula, and makes the brand a special brand, which is not entitled to representation in the tables of commercial brands. The Station has this year cut out all such erroneous samples, and, when possible, substituted true samples for them. There are six such samples at the close of the tables, for five of which duplicates could not be secured. They are therefore published separately; the sixth also is included because it was sampled unofficially. Unfortunately, the state of the case is usually not discovered until the analysis has been made, and thus a repetition of work is entailed. This extra work has been sufficient this year to delay the issue of the fertilizer bulletin thirty days, and the Station, therefore, cannot promise for the future that samples will be duplicated in time for the results to be included in the bulletin.

Of the brands published in the tables, it will be noticed that in a little over one-half of them the guarantee of phosphoric acid is defective, either available or total phosphoric acid alone being guaranteed. The absence of guarantee of total in certain instances is commercially not of great importance, since the difference between its figures and those of the available gives the amount of insoluble, which is comparatively inexpensive. Agriculturally, however, when consumers scrutinize guarantees, in order to select brands in which the quickly-available phosphoric acid is accompanied by a desired amount of more slowly-available phosphoric acid, the guarantee

giving this information is of particular value. But when, on the other hand, total phosphoric acid alone is guaranteed, there is no information whatever afforded as to its availability—a very important matter in the choice of a fertilizer. Attention was first called to this point in 1897, when the number of cases was 24. In 1898, there were 13; in 1899, 12; in 1900, 4; and in the present report there are 7 such cases. In certain ones a low available should be expected from their brand names; for example, "Fish and Potash," "Pure Bone Phosphate," etc. The reverse is not true, however, for purchasers have no reason to expect high availability in any brand simply because its name should happen to suggest it, or because other manufacturers put out material under the same brand name which has high availability. Consumers should request a compliance with the law in all respects before they consent to purchase.

The average amounts of plant-food guaranteed in the brands, and the average amounts found by analysis, are as follows:

	Total. Nitrogen. Per cent.	Available. Phos. Acid. Per cent.	Actual. Potash. Per cent.
Average guaranteed	2.17	7.60	5.34
Average found	2 31	8.08	5.75

From this it is evident that the fertilizers examined this year furnish, on the average, the amount of plant-food which they guarantee. A detailed examination of the tables shows, however, that many brands are furnishing much more than they guarantee, and thus cover up, in a consideration of averages, the shortcomings of others. It is poor comfort to a purchaser of one of the latter to hear that fertilizers on the average are up to guarantee, because what he loses his neighbor, perhaps, receives. Nevertheless, a scrutiny of the analysis of each brand, and a careful comparison of its actual composition with its accompanying guarantee, show that about 81 per cent. of them contain as much *total* plant-food as is claimed, but in only 65 per cent. of them is it distributed in the proportions which are stated. This is not as good a showing as usual, for the latter figure for the past three years has been, respectively, 71 for 1900, 69 for 1899, and 66 for 1898, or a steady improvement until this year.

The following table shows the number of brands deficient in one or more of the plant-food constituents compared with the same for 1895, 1896, 1897, 1898, 1899 and 1900. In compiling this table of deficiencies, any brand that failed to reach its guarantee of nitrogen by only 0.20 per cent., or its guarantee of phosphoric acid or potash by only 0.30 per cent., has not been included:

YEAR.	Number of Brands. Examined.	Found as guaranteed.	Found deficient.	Number of Deficiencies. Nitrogen.	Phosphoric Acid.	Potash.	Percentage Deficient.
1895	269	158	111	17	72	37	41
1896	329	211	118	30	62	56	36
1897	284	194	90	29	47	30	32
1898	303	201	102	43	29	49	34
1899	321	222	99	33	51	32	31
1900	298	214	84	33	35	31	29
1901	308	202	106	31	60	34	35

As indicated in the table, there are 125 deficiencies distributed among the 106 brands, 13 brands being deficient in two particulars and 3 brands in all three particulars of their guarantees. There are indeed many brands which, except for the allowances of two-tenths and three-tenths above stated, would be classed as deficient in more particulars than here reported.

Of the 106 considered deficient, 47 deliver the *value* of the plant-food guaranteed by containing an excess in some other form, showing a lack of skill or of carefulness in their preparation rather than an intent to defraud.

Station's Valuations and Selling Prices.

The Station's valuation per ton is derived by applying to the different constituents the schedule of prices already published; it is intended to show the retail cash cost of the amount of nitrogen, phosphoric acid and potash contained in one ton if they were bought at factory in the form of raw materials, unmixed. The difference between selling price and Station's value shows, therefore, the charge that is made for mixing, bagging, shipping and selling the several brands.

The selling price per ton entered in the tables is the price at the point where sampled. These prices differ in the various localities of

the State, due mainly to differences in freight rates from point of production to consumers' depot, the amount sold and commission charged. Nothing has been added to the valuations to represent these charges, the Station perferring to let the consumer make such calculations himself, whereby they will apply to his own conditions.

The average composition, estimated value and selling price of all of the brands of complete fertilizers examined each year for the past eleven years, together with the actual and the percentage difference by which the selling price exceeds the valuations, are shown in the following tabulation :

YEAR.	Total Nitrogen.	Total Phos. Acid.	Available Phos Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling price.	Actual difference.	Percentage difference.
1891	2 71	10.12	7.29	2 83	4 21	$25 31	$34 23	$8 92	35.2
1892	2.74	10.38	7 70	2 67	4 50	25 66	34 19	8 53	33 2
1893	2 69	10 23	7.54	2.69	4.58	24 41	34 11	9 70	39.7
1894	2.87	10.40	7.37	3 03	4.94	24 83	34 17	9 31	37.6
1895	2.80	10 74	7 84	2.90	4 80	24 15	32 87	8 72	36 1
1896	2 51	10.86	8.21	2 65	5.02	21 70	30 33	8 63	39.8
1897	2.54	10.93	8 01	2.91	5 01	21 58	29 28	7 70	35.7
1898	2 45	10 69	8 37	2 32	5.38	19 90	28 58	8 68	43.6
1899	2.41	10 58	8 27	2 31	5.67	19 95	27 75	7 80	39.1
1900	2.30	11.03	8.44	2.59	5.89	20 77	27 26	6 49	31.2
1901	2.31	10.48	8.08	2.40	5.77	21 19	27 31	6 12	28.9

It will be observed that the tendency of the average fertilizer toward a lower content of nitrogen is checked, notwithstanding an increase in the wholesale price of ammoniates ; manufacturers, as a whole, therefore, seem to have offset this increase by reducing the content of phosphoric acid and potash in their fertilizers, apparently believing that content of nitrogen has, on the average, reached its minimum, and that it would be bad policy to increase prices. The composition of the average fertilizer for 1901 may, therefore, be said to approximate to the following analysis :

Nitrogen	2.25	per cent.
Equal to Ammonia	2.75	"
Phosphoric Acid, total	10.50	"
" " available	8.00	"
Actual Potash	5.75	"
Equal to Sulfate of Potash	10.50	"

Station's Valuation, per ton	**$21 08**
Selling Price, per ton	**27 00**

As noted on a previous page, there have been increases in the schedule for the valuation of complete fertilizers, whereby two of the forms of nitrogen, as well as both forms of available phosphoric acid, are given higher values than last year, as follows :

	Valued in 1900 at	Valued in 1901 at
Nitrogen in Nitrates	*13.5 cents.*	*14.0 cents.*
" " Ammonia Salts	17.0 "	16.5 "
" " Organic Matter	15.5 "	16.0 "
Phosphoric Acid, soluble in water	4.5 "	5.0 "
" " " " ammonium citrate	4.5 "	5.0 "

The price for the valuation of potash, however, remains the same. It becomes of interest, therefore, to determine whether there is an equivalent amount of plant-food delivered with this change in the average formula. This is readily determined by calculating the valuation of the average complete fertilizer of each of the two years by means of the same schedule. In this manner the Station's valuations, calculated for the two years, according to last year's schedule, compared with the selling prices, are shown as follows :

	Station's Valuation.	Selling Price.	Actual Difference.
1900	$20 77	$27 26	$6 49
1901	20 19	27 31	7 12

From this it appears that the manufacturers are delivering on the average somewhat less total plant-food than in 1900, but at about the same price per ton. The increase in the schedule of valuations brings the average actual difference and the percentage difference lower than ever before. These differences have been remarkably uniform in the past, which renders it worthy of note that the rise in the cost of raw materials, and the consequent increase in the schedule of valuations, have not been accompanied by a marked increase in the average selling price.

Taking the valuations and selling prices as they are, however, the average difference is $6.12, which represents the average charge of the entire number of manufacturers for mixing and bagging an average of about $21 worth of plant-food, and for the expenses incurred in a great variety of ways in effecting its sale and delivery. That manufacturers do not make this average charge in all cases is apparent from an examination of the tables. Thus, there will be found 7 brands in which the value of the plant-food at Station's prices is equal to or greater than the price reported, 148 other brands in which the differ-

ence is still below the average, namely, $6.12, 36 more with a difference of $7, 35 with a difference of $8, 27 differing by $9, 14 by $10, 13 by $11, 11 by $12, and 16 differing by from $13 upwards, all approximately.

In calling attention to this wide range of difference between Station's valuation and the selling price, the Station wishes not only to emphasize the fact that plant-food has been and is being purchased at or below the Station's schedule of prices, but also to warn the reader against the hasty conclusion on the other hand, that fraud enters into the transaction when the selling price exceeds the valuation. It may be that there are cases in which guarantees are given and fulfilled, and yet an extravagant price shrewdly asked for the goods, entirely out of proportion to the amount of plant-food offered ; yet, on the other hand, it must be remembered that the selling prices in the tables are those reported from the places where the goods were sampled. In most cases they include, therefore, not only the factory expenses of mixing and bagging, the office expenses, the salaries of clerks and bookkeepers, but also the freight and the local agent's commissions, none of which are included in the Station's valuation. Besides these, also, the selling price includes in many instances, in addition to the expenses of getting the fertilizer on the market, the expenses of a more or less successful collection of the payment for the same. The Station could note numerous cases in which lower prices for cash are quoted, and farmers buying a bag at a time on indefinite credit cannot hope for as favorable rates as those who club together to buy a carload for spot cash, whereby all the expenses from the time the goods leave the manufacturer's warehouse until the payment reaches his office are reduced to a minimum. Under these circumstances, few, if any, of the large manufacturers will decline to sell at about the Station's valuation, and there are numerous instances on record of their having done so, as may be gathered from the succeeding paragraph.

2. The Examination of Home Mixtures and Special Compounds.

Home mixing has been carried on with entire satisfaction by a number of farmers for several years. The Station has encouraged these efforts as of value to the individuals themselves and an object-lesson to their neighbors, since it renders them familiar with the kinds and forms of plant-food, teaches them to think of pounds of nitrogen, phosphoric acid and potash, rather than tons of a particu-

lar phosphate, and in general unfolds the mystery which envelops the make-up of fertilizers in the minds of many.

For similar reasons, the Station has assisted by making the analysis of complete fertilizers specially compounded for farmers by the regular manufacturers. In the case of most of these mixtures, the analysis desired, or the raw material to be used, was specified by the purchaser and guaranteed by the manufacturer. The ingredients used in the home mixtures were, so far as reported to us, as follows :

Composition of Home Mixtures.

No. 1090.

100 lbs. Nitrate of Soda.
1,200 " Chicken Manure.
550 " Acid Phosphate.
150 " Muriate of Potash.

No. 1580.

975 lbs. Dried Fish.
800 " Acid Phosphate.
225 " Muriate of Potash.

No. 1581.

160 lbs. Nitrate of Soda.
240 " Dried Blood.
1,240 " Acid Phosphate.
360 " Muriate of Potash.

No. 1505.

200 lbs. Nitrate of Soda.
100 " Sulfate of Potash.
100 " Dried Blood.
1,200 " Degelatinized Bone.
400 " Muriate of Potash.

No. 1583.

1,440 lbs. Ground Bone.
560 " Muriate of Potash.

The analyses of the home mixtures and of the specially compounded mixtures are to be found on a subsequent page among the tables. The most striking fact which may be learned from a study of them is shown in the following comparison of the average composition, valuation and cost of the home mixtures, of the special compounds and of the regular commercial brands :

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling price or cost.	Actual difference.	Percentage difference.
Special Compounds..	2.24	12.08	9.71	2.37	6.16	$23 15	$24 44	$1 29	5.6
Home Mixtures	2.43	11.39	8.66	2.73	6.86	23 34	26 00	2 66	11.4
Regular Brands.	2.31	10.48	8.08	2.40	5.77	21 19	27 31	6 12	28.9

The table shows that, on the average, the regular brands sold at an advance over Station's valuation of 28.9 per cent., the home mixtures cost at an advance of 11.4 per cent. and the special compounds at an advance of 5.6 per cent. In other words, $100 worth of plant-food, according to the Station's schedule of prices (which are wholesale prices plus 18 per cent.), cost $105.60 when purchased in the form of special compounds, $111.40 in the form of home mixtures, and 128.90 in the form of regular commercial brands. Moreover, the range in the relation of price to guarantee is narrower in the former two than in the latter; for the greatest individual advance of selling price over valuation is $6.19 in the home mixtures, and $10.53 in the special compounds, whereas in the regular commercial brands the average advance was $6.12, and 40 brands had a difference of $11 or more.

This indicates the advantage of either home mixing or of special mixing by the manufacturer to suit the wants of the consumer. The saving by these methods is great; to use them to advantage, however, the farmer must have definite knowledge as to the requirements of his soils and crops, and in supplying the same must use business-like methods in the purchase of his fertilizer supplies.

Among the special compounds are a number which were prepared by I. P. Thomas & Son Co., and which bear the same brand name and guarantee as certain of their regular brands. The analyses of the regular brands are to be found in their regular places in the tables. These brands are inserted here because they are special compounds, having been fortified, or improved, by being made stronger for particular customers. It will be noticed that these have also undergone an advance in price, but it should also be noticed that while the improvement consists in the supplying of about 42 per cent. more plant-food, the price has been increased only 6 per cent., a difference of 36 per cent. There is no reason to believe that any of the manufacturers would decline to make this concession to large sales and quick profits.

3. Ground Bone.

The samples of ground bone examined this year are, with exceptions, of as good composition, but not of as good quality as regards fineness as last year. There are only five, or one-fifth, of them in which two-thirds of their material will pass the sieve, whereas last year there were thirteen such, equal to one-half the brands examined. Several are not accompanied by a guarantee as required by law, but

in most of these cases, as well as in those in which the guarantee is not fulfilled, the analysis shows them to contain a sufficient quantity of plant-food to render an equivalent of value. One notable exception must have attention directed to it; sample No. 0125 was found to have a much lower quality than should be expected from the price. Investigation disclosed that it contains considerable substance that is not bone. The matter was communicated to the manufacturer, who immediately ordered a rebate to those to whom it had been sold. This sample, and two others which are samples of 1900, analyzed too late for last year's bulletin, are excluded from consideration when calculating averages.

The average fineness and composition of the samples this year, as compared with 1899 and 1900, is shown as follows:

	Fine. Per cent.	*Coarse.* Per cent.	*Nitrogen.* Per cent.	*Phosphoric Acid.* Per cent.
Average for 1899......	49	51	3.17	22.83
" " 1900......	63	37	3.24	23 33
" " 1901......	52	48	3.20	24.20

The composition of the different samples (three excluded as noted) varied from 1.45 to 5.38 per cent. of nitrogen and from 17.50 to 28.70 per cent. of phosphoric acid. There is somewhat of a relation between the two, a high nitrogen content being usually accompanied by a low phosphoric acid, and *vice versa*, but this relation is by no means invariable.

Valuation of Bone.

In the schedule of valuations of bone this year, three changes were made, an increase of half a cent for the nitrogen in the finer grade, and of one cent each for both nitrogen and phosphoric acid in the coarser grade.

The following table shows the schedule used as compared with that of 1900:

	Nitrogen. Per pound.		Phos. Acid. Per pound.	
	1900. cts.	1901. cts.	1900. cts.	1901. cts.
Finer than 1-50 inch...............	15.5	16.0	4.0	4.0
Coarser " 1-50 "	11.0	12.0	2.0	3.0

An examination of the valuations given in the table shows that they vary from $19.93 to $32.60 per ton, while the selling prices range from $22 to $35. The average valuation and average selling price is compared with the same figures for 1899 aud 1900, as follows :

Year.	Station's Value.	Selling Price.	Difference.
1899	$21 24	$28 20	$6 96
1900	25 88	28 70	2 82
1901	26 09	28 98	2 89

The excess of selling price over valuation is much less in ground bone than in complete fertilizers, being about 11 per cent., whereas that in complete fertilizers is about 29 per cent. The nitrogen and phosphoric acid in ground bone, therefore, are still much cheaper than when bought in the form of complete fertilizers.

4. Miscellaneous Fertilizers.

Of the 17 samples of miscellaneous fertilizers, one is a complete fertilizer analyzed too late to be included in the regular classification, 7 represent commercial materials furnishing nitrogen and phosphoric acid, and 8 furnishing phosphoric acid and potash ; they consist either of true dissolved bone or plain superphosphate of lime, with ammoniates or potash salts added. There is one plain superphosphate. As in the case of complete fertilizers, the brand names of many of these materials are misleading. Samples branded "dissolved bone," "soluble bone," "alkaline bone," etc., may contain no animal bone as such, but plain rock superphosphate. Particular reference to the guarantee should be made in these, and, indeed, in all instauces. In most of those which are accompanied by a guarantee, the actual analysis substantiates the same. Several of these preparations are not economical sources of plant-food, although the majority are much better than the average complete fertilizer in this respect. From an agricultural standpoint, care is required in the use of these unbalanced mixtures. In the case of the plain superphosphate, no valuation has been affixed ; the cost per pound of available phosphoric acid, calculated from the content and from the selling price, is 7.9 cents.

The 9 samples of wood ashes examined show the usual variations in content of potash, although their phosphoric acid is quite uniform. Still the recognized favorable effect of wood ashes is undoubtedly due as much to the lime contained as to the phosphoric acid and

potash. To farmers who desire to apply lime, wood ashes have an increased value, dependent upon the price at which they can purchase the lime in other forms in their own neighborhood. This value the Station does not undertake to determine, and hence the valuations of wood ashes are based only upon their content of phosphoric acid and potash, at the rate of 4 cents and 5 cents per pound, respectively. The lime which accompanies them may be more or less expensive. Allowing Station's valuations for the phosphoric acid and potash, the lime cost in the various samples from 35 cents to $1.03 per hundred weight, and almost invariably cost less as the amount of phosphoric acid and potash increased.

The remainder of the miscellaneous materials are factory wastes or natural products, which were examined to determine their character as sources of plant-food. They include three samples of wool waste, five of marl, and one each of snuff sand, garbage refuse and common lime. Their analyses will be found on the pages at the end of the tables.

Immediately following will be found the analyses of six samples of complete fertilizers, of which five are manifestly fortified goods, and probably for special customers, although this fact could not be definitely ascertained. The results are published separately, on account of this lack of knowledge. With them is a sample of Evans Brand, Potato Manure; this was sampled by a private party and analyzed at bis request, and a duplicate sample was analyzed for the regular report.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
J. H. Allen, Lawrence Station, N. J.		
Complete Phosphate	J. M. Dalrymple	1354
Potato and Truck Manure	"	1376
American Agricultural Chemical Co., New York City.		
H. J. Baker and Bro. Branch.		
Harvest Home	J. J. Mitchell	1511
Vegetable, Vine and Potato	H. S. Van Nuys	1165
Standard UNXLD Fertilizer	J. Heck	1221
High-Grade Special	J. J. Mitchell	1514
Corn and Oats Manure	J. Heck	1224
Potato Manure	J. M. Dalrymple	1248
Bradley Fertilizer Co. Branch.		
Potato Fertilizer	D. N. Warbasse	1432
Complete Fertilizer, New Method	J. J. Mitchell	1517
Potato Manure	"	1518
Patent Superphosphates	"	1520
Chemical Co. of Canton Branch.		
Truckers' Delight	C. Kraus	1562
Chicopee Guano Co. Branch.		
Farmers' Reliable	J. B. Ward	1598
Standard	"	1599
A 1 Vegetable and Potato Manure	"	1600
Great Eastern Fertilizer Co. Branch.		
Garden Special	C. C. Hulsart	1089
Vegetable, Vine and Tobacco	J. Heck	1213
Pacific Guano Co. Branch.		
High-Grade General	H. S. Van Nuys	1176
Ammoniated Dissolved Bone	"	1177
Packers' Union Fertilizer Co. Branch.		
Universal Fertilizer	C. Kraus	1570
Animal Corn Fertilizer	J. M. Dalrymple	1366
Potato Manure	H. O. Newcomb	1058
Gardners' Complete Manure	S. Wood	1106
Moro Phillips Fertilizer Co. Branch.		
Sweet Potato Phosphate	J. H. Richardson	1465
Preston Fertilizer Co. Branch.		
Tomato Guano	H. O. Newcomb	1150
Pioneer Fertilizer	H. I. Budd	1287
Lawn Dressing	"	1288

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.		
0.40	......	2.16	2.56	2.46	6.90	2.78	2.03	11.71	12.00	9.68	10.00	*2.63	2.00	$21 16	$25 00
1.18	......	1.91	3.09	3.28	5.18	2.82	0.88	8.88	10.00	8.00	7.00	*10.08	10.00	27 84	32 00
0.32	......	0.79	1.11	1.03	6.26	2.54	2.08	10.88	9.00	8.80	8.00	2.41	2.00	15 11	23 00
0.80	0.38	1.34	2.52	2.46	6.56	0.55	0.42	7.53	7.00	7.11	6.00	10.71	10.00	24 16	30 00
0.26	......	1.83	2.09	2.05	7.88	0.92	0.69	9.49	9.00	8.80	8.00	3.76	3.00	18 87	33 00
0.59	0.72	1.76	3.07	3.28	6.96	2.06	0.98	10.00	9.00	9.02	8.00	6.73	7.00	24 77	38 00
1.05	1.02	1.90	3.97	4.10	7.00	0.83	0.61	8.44	8.00	7.83	7.00	7.13	7.00	26 51	36 00
0.82	0.92	1.50	3.24	3.28	5.28	1.64	1.52	8.44	7.00	6.92	6.00	10.23	10.00	26 37	31 00
0.81	......	1.42	2.23	2.05	2.62	5.09	3.84	11.55	9.00	7.71	8.00	3.69	3.00	19 11	27 50
......	......	1.27	1.27	0.82	4.44	3.82	3.91	12.17	9.00	8.26	8.00	2.51	2.00	16 01	27 00
0.89	......	1.67	2.56	2.46	2.42	2.87	4.01	9.30	7.00	5.29	6.00	7.12	6.00	20 77	30 00
0.26	......	2.13	2.39	2.05	3.00	4.03	4.45	11.48	10.00	7.03	8.00	2.26	1.50	16 29	25 00
0.71	......	1.64	2.35	2.46	6.18	2.08	1.88	10.14	9.00	8.26	8.00	3.80	4.00	19 48	30 00
0.20	......	0.94	1.14	0.82	7.02	2.00	2.64	11.66	8.00	9.02	7.00	2.00	1.00	15 35	23 00
......	......	0.94	0.94	0.82	6.86	1.54	2.69	10.59	....	7.90	8.00	3.52	4.00	14 99	26 00
0.74	......	1.84	2.58	2.46	5.92	2.08	1.85	9.85	....	8.00	6.00	6.11	6.00	21 89	33 00
1.02	......	2.61	3.63	3.28	6.80	1.50	1.77	10.07	....	8.30	7.00	6.86	7.00	26 05	33 00
......	......	2.07	2.07	2.05	4.82	4.29	2.75	11.86	9.00	9.11	8.00	3.98	3.00	20 21	28 00
0.85	0.65	1.91	3.41	3.28	4.28	8.65	2.73	10.66	9.00	7.93	8.00	7.86	7.00	26 34	30 00
0.36	0.36	1.04	1.76	1.64	4.96	3.23	3.47	11.66	....	8.19	8.00	2.56	2.00	17 29	23 00
......	......	1.08	1.08	0.82	4.98	3.08	2.02	10.08	9.00	8.06	8.00	4.34	4.00	16 01	25 00
......	......	2.39	2.39	2.46	6.92	2.00	2.12	11.04	10.00	8.92	9.00	4.79	2.00	21 49	26 00
0.50	......	1.57	2.07	2.05	6.84	2.03	1.82	10.69	9.00	8.87	8.00	6.07	6.00	21 18	28 00
......	1.40	2.03	3.43	3.28	5.60	2.18	1.69	9.32	7.00	7.63	6.00	9.37	10.00	27 40	31 00
0.32	......	1.36	1.68	1.64	6.62	1.70	1.37	9.69	9.00	8.32	8.00	10.77	10.00	23 28	29 00
0.47	......	1.17	1.64	1.64	4.18	4.16	1.95	10.29	....	8.34	6.00	3.43	3.00	17 09	25 00
0.34	......	0.62	0.96	1.03	5.92	2.08	1.39	9.39	9.00	8.00	8.00	2.31	2.00	13 45	22 00
1.48	......	1.63	3.11	3.28	4.44	2.48	1.65	8.57	....	6.92	8.00	9.23	7.00	24 78	36 00

*Potash largely, if not entirely, in form of sulfate. See page 88.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND	SAMPLER.	Station Number.
American Agricultural Chem. Co.—(Cont.)		
The Quinnipiac Co. Branch.		
Climax Phosphate	W. Pettit	1658
Complete Potato Manure	"	1659
Mohawk Fertilizer	"	1660
Market Garden	"	1661
Read Fertilizer Co. Branch.		
Vegetable and Vine Phosphate	H. I. Budd	1289
Farmers' Friend Superphosphate	"	1290
Leader Blood and Bone	A. Dilts	1423
Potato Special	W. O. Ward	1344
Sharpless & Carpenter Branch.		
Dissolved Bone Phosphate	H. O. Newcomb	1012
No. 1 Bone Phosphate	J. H. Richardson	1469
Gilt Edge Potato and Tobacco Manure	H. I. Budd	1623
Potato, Corn and Truck	"	1624
Susquehanna Fertilizer Co. Branch.		
Potato Phosphate	W. O. Ward	1345
Tygert-Allen Fertilizer Co. Branch.		
Superior Ground Fish Guano	H. O. Newcomb	1014
Star Bone Phosphate	C. Kraus	1575
Popular Phosphate	S. Wood	1091
Potato Manure	"	1092
Special Potato	J. C. Griscom	1115
Sweet Potato Manure	"	1116
Soluble Marine Guano	"	1118
Williams & Clark Fertilizer Co. Branch.		
Good Grower Potato Phosphate	H. S. Van Nuys	1188
Potato Phosphate	"	1185
Royal Bone Phosphate	D. N. Warbasse	1458
Prolific Crop Producer	A. Dilts	1429
Americus Universal Ammoniated Dissolved Bone	J. Heck	1225
Armour Fertilizing Works, Chicago, Ill.		
All Soluble	S. Wood	1093
Manure Substitute	J. J. Mitchell	1507
High Grade Potato	J. Heck	1200
Fruit and Root Fertilizer	A. Dilts	1456
Ammoniated Bone with Potash	"	1408
Cortelyou's Wheat and Rye Special	H. S. Van Nuys	1350

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	1.06	1.06	1.03	4.70	2.85	2.09	9.64	....	7.55	8.00	2.16	2.00	$13 62	$18 00
0.63	......	1.61	2.24	2.46	5.04	1.25	1.21	7.50	....	6.29	6.00	5.91	6.00	18 71	24 00
......	......	0.86	0.86	0.82	4.02	2.06	1.55	7.63	....	6.08	7.00	1.07	1.00	10 36	16 50
1.20	......	1.77	2.97	3.28	4.90	3.16	2.07	10.13	....	8.06	8.00	6.76	7.00	23 66	25 00
0.39	......	1.76	2.15	2.05	6.64	2.55	1.63	10.82	9.00	9.19	8.00	6.33	6.00	21 94	28 00
0.34	0.24	1.71	2.29	2.05	6.76	2.83	1.27	10.36	9.00	9.09	8.00	3.42	3.00	19 72	25 00
......	......	1.21	1.21	0.82	2.68	4.55	3.50	10.73	8.00	7.23	7.00	1.59	1.00	13 85	22 00
......	......	1.41	1.41	0.82	2.50	1.56	1.55	5.61	5.00	4.06	4.00	7.50	8.00	15 57	25 00
0.47	......	1.60	2.07	2.05	6.56	2.45	1.57	10.58	....	9.01	6.00	6.52	6.00	21 62	28 00
......	0.28	1.34	1.62	1.64	4.14	8.61	2.59	10.34	10.00	7.75	8.00	2.23	2.00	15 93	28 00
0.32	0.20	1.20	1.72	1.64	6.14	1.86	1.66	9.66	9.00	8.00	8.00	10.36	10.00	22 87	27 00
0.20	0.22	0.99	1.41	1.23	3.68	2.73	1.55	7.96	7.00	6.41	6.00	5.31	5.00	16 00	24 00
......	......	1.62	1.62	1.64	5.20	2.50	2.01	9.71	9.00	7.70	8.00	5.88	5.00	18 67	27 00
0.43	0.25	1.18	1.86	1.83	2.56	3.07	1.60	7.23	....	5.63	5.00	1.81	1.00	13 62	22 00
0.70	......	1.45	2.15	2.05	5.12	3.29	1.80	10.21	9.00	8.41	8.00	3.41	3.00	18 63	25 00
......	0.21	0.71	0.92	0.82	5.10	2.68	1.48	9.21	9.00	7.78	8.00	2.12	2.00	13 11	25 00
......	1.49	1.82	3.31	3.28	5.10	2.48	1.99	9.57	7.00	7.58	6.00	9.52	10.00	27 21	30 00
0.47	0.23	1.49	2.19	2.05	5.94	2.72	1.75	10.41	....	8.66	8.00	5.72	6.00	21 07	27 00
0.46	......	1.42	1.88	1.64	6.94	2.38	1.88	10.20	10.00	8.32	8.00	10.23	10.00	23 60	28 00
1.30	0.23	1.84	3.37	3.28	5.12	3.25	1.83	10.20	....	8.37	8.00	7.24	7.00	25 54	33 00
......	......	1.43	1.43	1.23	4.16	3.64	3.24	11.04	8.00	7.80	6.00	6.99	5.00	19 62	27 00
0.80	......	1.78	2.58	2.46	2.06	4.11	3.04	9.21	7.00	6.17	6.00	*7.45	6.00	21 86	27 00
......	.....	1.35	1.35	1.03	3.94	4.03	2.55	10.52	9.00	7.97	8.00	2.26	2.00	15 23	25 00
......	.....	1.14	1.14	0.82	5.78	1.43	1.47	8.68	8.00	7.21	7.00	1.37	1.00	12 61	21 00
......	.....	1.96	1.96	1.64	4.58	3.61	4.31	12.50	9.00	8.19	8.00	2.34	2.00	18 17	24 00
0.76	......	2.50	3.26	2.87	6.22	3.02	0.72	9.96	....	9.24	8.00	*5.63	4.00	25 29	32 00
......	......	4.55	4.55	3.28	4.08	2.98	1.08	8.14	....	7.06	6.00	5.25	4.00	26 51	34 00
......	......	1.61	1.61	1.64	5.06	3.93	3.07	12.06	10.00	8.99	8.00	7.58	10.00	21 79	30 00
......	......	1.89	1.89	1.64	4.20	3.79	2.49	10.48	10.00	7.99	8.00	5.85	5.00	20 01	25 00
0.42	......	1.92	2.34	2.46	3.88	3.64	1.67	9.19	8.00	7.52	6.00	2.90	2.00	17 98	25 00
......	......	1.67	1.67	1.64	7.22	2.75	1.21	11.18	....	9.97	8.00	2.08	2.00	17 58	20 00

* Potash largely, if not entirely, in form of sulfate. See page 38.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
Armour Fertilizing Works.—(Cont.)		
Grain Grower	J. M. Dalrymple	1355
Corn, Wheat and Oats Special	"	1356
Warren Atkinson, Mullica Hill, N. J.		
High Grade Po ato Fertilizer	S. Wood	1095
Special Sweet Potato	J. C. Griscom	1120
Potato and General Truck	"	1121
Special Early Tomato Grower	"	1122
Cabbage and Tomato	"	1123
James H. Baird, Marlboro, N. J.		
Potato Manure	H. D. Hance	1629
Asparagus Manure	"	1630
Grass Mixture	"	1631
Baugh and Sons Co., Philadelphia, Pa.		
Animal Bone and Potash	H. I. Budd	1276
$25 Phosphate	"	1277
General Crop Grower for All Crops	"	1278
The Berg Co., Philadelphia, Pa.		
Electric $35 Potato Manure	C. Kraus	1560
Cyclone Bone Manure	"	1561
Standard Bone Manure	J. M. Dalrymple	1476
Special $25 Bone Manure	"	1475
Lymph Guano	H. I. Budd	1611
Berger Bros., Easton, Pa.		
Peerless Phosphate	W. O. Ward	1324
Potato and Truck	"	1325
Bowker Fertilizer Co., Boston, Mass.		
Hill and Drill	H. D. Hance	1638
Potato and Vegetable Manure	J. M. Dalrymple	1478
Bone and Potash, Square Brand	"	1477
Sweet Potato and Truck	H. O. Newcomb	1036
Market Garden	"	1142
Farm and Garden Phosphate	W. O. Ward	1328
Early Potato Manure	J. Heck	1204
Potato and Vegetable Phosphate	"	1206
Stockbridge Corn Manure	"	1209
Stockbridge Potato Manure	H. I. Budd	1279
Stockbridge Top Dressing	F. E. Woodruff	1379
Lawn and Garden Dressing	"	1380
Fish and Potash, Square Brand	"	1381

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	1.73	1.73	1.64	5.76	2.61	2.07	10.44	10.00	8.37	8.00	1.94	2.00	$16 39	$23 00
......	......	0.77	0.77	0.82	5.70	2.64	1.76	10.10	9.00	8.34	8.00	1.58	1.00	12 84	21 00
0.49	1.09	2.11	3.69	3.28	7.90	2.93	1.01	11.84	11.00	10.83	8.00	6.96	7.00	28 87	32 00
0.40	......	1.54	1.94	1.64	5.18	3.62	2.90	11.70	10.00	8.80	8.00	10.52	10.00	24 95	28 00
0.79	......	2.02	2.81	2.46	7.60	2.21	1.94	11.75	10.00	9.81	7.00	7.42	7.00	26 57	28 00
2.58	0.23	2.34	5.15	5.33	7.26	1.60	0.66	9.52	8.00	8.36	7.00	5.35	4.00	29 14	32 00
0.64	......	2.17	2.81	2.46	4.88	8.78	2.93	11.59	9.00	8.66	7.00	6.65	6.00	23 36	26 00
1.02	1.47	0.88	3.37	3.28	4.74	3.91	1.75	10.40	....	8.65	8.00	9.89	10.00	28 29	30 00
3.08	0.32	3.49	6.89	6.56	1.14	7.06	1.42	9.62	....	8.20	5.00	3.61	2.00	32 69	33 50
6.86	......	2.26	9.12	8.20	1.46	4.50	0.60	6.56	....	5.99	3.00	5.40	5.00	37 23	35 00
......	......	1.92	1.92	1.64	5.20	8.23	2.23	10.66	....	8.43	8.00	2.23	2.00	17 36	23 00
......	......	1.71	1.71	1.64	4.44	4.58	2.45	11.47	....	9.02	8.00	1.16	1.00	16 46	25 00
......	......	1.13	1.13	0.82	5.24	3.44	2.24	10.92	....	8.68	8.00	1.42	1.00	14 41	20 00
0.33	......	1.69	2.02	2.46	4.02	6.11	4.64	14.77	9.00	10.13	7.00	7.72	8.00	24 88	32 72
......	......	2.04	2.04	2.46	3.50	4.45	2.87	10.82	9.00	7.95	7.00	2.69	3.00	17 92	30 00
0.20	......	1.64	1.84	2.46	4.16	4.68	3.67	12.51	10.00	8.84	8.00	5.07	6.00	20 43	28 00
......	......	1.59	1.59	1.64	3.24	5.40	3.79	12.43	9.00	8.64	7.00	2.12	2.00	17.05	24 00
0.66	......	1.71	2.37	2.87	3.82	5.49	3.42	12.73	9.00	9.31	7.00	3.60	3.00	25 31	33 00
......	......	1.10	1.10	0.82	3.68	4.76	1.38	9.82	10.00	8.44	8.00	2.58	2.00	14 70	20 00
1.38	......	1.86	3.24	3.69	5.38	3.05	1.58	10.01	10.00	8.43	8.00	6.03	6.00	24 00	32 50
0.81	......	1.77	2.58	2.46	5.54	4.00	1.70	11.24	12.00	9.54	9.00	2.33	2.00	20 13	31 00
......	......	2.37	2.37	2.25	5.48	2.82	1.86	10.16	11.00	8.30	9.00	3.96	4.00	19 93	30 00
......	......	1.54	1.54	1.64	1.94	4.48	6.75	13.17	10.00	6.42	6.00	1.95	2.00	15 71	24 00
0.42	......	1.20	1.62	1.64	4.02	2.61	1.90	8.53	....	6.63	6.00	7.90	8.00	19 13	28 00
0.72	......	1.62	2.34	2.46	3.82	2.86	2.78	9.41	7.00	6.68	6.00	10.63	10.00	24 00	35 00
0.26	......	1.42	1.68	1.64	6.88	4.11	2.48	13.47	11.00	10.93	9.00	2.13	2.00	19 06	25 00
1.41	......	1.82	3.23	3.28	6.08	1.91	1.78	9.77	9.00	7.99	7.00	7.17	7.00	24 57	33 00
0.26	......	1.56	1.82	1.50	5.52	2.25	2.75	10.52	11.00	7.77	9.00	2.09	2.00	16 36	23 00
1.14	......	2.09	3.23	3.28	6.62	1.70	0.99	9.31	9.00	8.32	7.00	7.15	7.00	24 68	36 00
1.60	......	1.51	3.11	3.28	6.84	2.10	1.80	10.74	8.00	8.94	6.00	*10.41	10.00	29 38	33 00
2.52	......	2.29	4.81	4.92	3.80	3.07	1.75	8.62	6.00	6.87	6.00	6.37	6.00	27 38	35 00
3.52	......	0.53	4.05	3.28	4.88	1.45	1.08	6.91	8.00	5.83	6.00	5.32	5.00	22 35	35 00
......	......	2.45	2.45	2.25	1.22	4.13	2.28	7.58	8.00	5.35	....	4.46	4.00	17 87	30 00

* [illegible]

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
Bowker Fertilizer Co.—(Cont.)		
Bone and Wood Ash Fertilizer	S. Wood	1097
Sure Crop Phosphate	A. Dilts	1458
Potash-Bone	W. O. Ward	1830
Bradley & Green Fertilizer Co., Philadelphia, Pa.		
Special Potato Manure	H. I. Budd	1060
Wm. B. Brown, Cedarville, N. J.		
Special Potato	H. O. Newcomb	1401
E. Frank Coe Co., New York City.		
Excelsior Potato Fertilizer	F. E. Woodruff	1887
Excelsior Guano Red Braud	H. S. Van Nuys	1169
High-Grade Potato	J. J. Mitchell	1522
Original Ammoniated Dissolved Bone Phosphate	J. M. Dalrymple	1228
Extra Special Potato Fertilizer	W. T. Woerner	1300
New England Special Corn Fertilizer	J. M. Dalrymple	1243
Ground Boue and Potash	A. Dilts	1409
Special for All Crops	"	1410
Alkaline Bone Phosphate	H. I. Budd	1062
High-Grade Fish and Potash	"	1616
Peach Tree, Grape and Vine	H. D. Hance	1641
John S. Collins & Son, Moorestown, N. J.		
High-Grade Fertilizer for Potatoes and General Use	H. I. Budd	1063
Cabbage and Tomato Fertilizer	"	1065
Fish Guano	"	1068
Collins & Pancoast, Merchantville, N. J.		
Cabbage and Tomato Fertilizer	S. Wood	1099
High-Grade Fertilizer for Potatoes	"	1100
Fish Guano	"	1102
I. S. Curtis, Frenchtown, N. J.		
High-Grade Bone Phosphate	A. Dilts	1411
$20-Phosphate	"	1412
Davis, Colson & Co., Woodstown, N. J.		
High-Grade Potato and Truck	W. Pettit	1251
High-Grade Bone Phosphate	"	1252
Special Corn Mixture	"	1253
Potato and Tomato Fertilizer	"	1254
B. F. Demarris & Son, Cedarville, N. J.		
Special Berry Manure	H. O. Newcomb	1039
Special Superphosphate	"	1041

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.40	0.49	0.67	1.56	1.50	......	5.37	5.17	10.54	8.00	6.37	6.00	*2.24	2.00	$14 56	$26 00
......	......	0.86	0.86	0.75	2.44	5.23	8.93	11.60	11.00	7.67	9.00	2.07	2.00	13 76	20 00
0.20	......	0.72	0.92	0.82	2.69	3.31	2.54	8.43	8.00	5.91	6.00	2.12	2.00	11 60	20 00
......	0.25	1.94	2.19	2.46	4.32	3.92	3.15	11.39	......	8.24	8.00	8.41	8.00	23 69	27 00
0.79	......	1.53	2.32	2.46	5.04	3.22	1.46	9.72	10.00	8.26	......	9.29	7.00	23 85	30 00
......	0.84	1.61	2.45	2.46	5.80	0.99	2.69	8.98	8.00	6.29	7.00	*8.20	8.00	23 49	37 00
......	1.04	2.17	3.21	3.28	7.80	1.06	2.41	10.77	10.50	8.36	9.00	*7.80	6.00	27 49	36 00
......	0.40	1.94	2.34	2.46	6.14	1.18	8.58	10.80	9.00	7.27	7.00	*8.07	6.50	24 28	34 00
......	......	1.70	1.70	1.23	7.22	1.18	3.75	12.10	......	8.35	10.00	*2.36	2.25	17 65	25 00
......	0.53	1.19	1.72	1.64	7.06	1.66	2.97	11.69	9.50	8.72	8.00	*8.06	10.00	23 53	32 00
......	......	1.18	1.18	0.82	4.48	2.66	3.99	11.13	8.50	7.14	7.00	*3.55	3.00	16 07	21 00
......	0.29	2.34	2.63	1.64	......	6.63	7.43	14.06	14.00	6.63	11.00	2.75	2.00	20 59	30 00
......	......	1.22	1.22	1.23	7.00	1.27	3.85	12.12	10.00	8.27	8.50	*2.18	2.00	15 89	22 00
......	......	1.54	1.54	1.23	6.76	1.52	3.60	11.88	10.00	8.28	8.50	*3.10	2.50	17 75	26 00
......	......	2.49	2.49	2.46	2.66	3.31	6.34	12.31	10.00	5.97	7.00	*2.43	2.00	18 91	30 00
......	0.23	1.30	1.53	1.23	6.26	1.37	2.87	10.50	8.00	7.63	......	*5.17	5.00	18 87	27 00
0.77	......	1.88	2.65	2.46	6.84	2.15	0.87	9.86	......	8.99	8.00	*11.16	10.00	28 68	28 00
1.48	......	1.69	3.17	3.28	2.16	5.61	1.72	9.49	......	7.77	7.00	*5.93	5.00	23 40	27 00
0.77	0.24	1.38	2.39	2.46	6.22	2.40	1.69	10.31	......	8.62	8.00	4.21	4.00	20 25	26 00
0.85	......	2.32	3.17	3.28	2.44	5.51	3.63	11.58	......	7.95	7.00	*6.36	5.00	25 39	28 00
1.12	......	1.81	2.93	2.46	5.82	3.02	1.05	9.89	......	8.84	8.00	*10.24	10.00	27 34	28 00
1.12	......	2.79	3.91	2.46	4.60	4.02	1.87	10.49	......	8.62	8.00	3.71	4.00	24 59	25 00
1.27	......	1.61	2.88	1.64	5.90	1.80	1.58	9.28	......	7.70	8.00	4.62	3.00	20 97	28 00
0.56	......	1.10	1.66	0.82	4.60	2.99	2.18	9.72	......	7.59	6.00	4.96	2.00	17 75	20 00
0.69	0.21	2.42	3.32	3.69	5.50	1.88	2.89	10.27	......	7.38	8.00	7.41	7.00	25 20	29 00
0.58	......	1.94	2.52	2.46	8.44	0.80	0.94	10.18	......	9.24	9.00	7.11	5.00	23 49	28 00
1.01	......	1.91	2.92	2.87	7.44	0.96	1.99	10.39	......	8.40	7.00	4.86	3.00	22 27	22 00
0.82	......	2.37	3.19	2.46	4.28	3.13	2.62	10.03	......	7.41	8.00	6.76	5.00	24 09	24 00
4.16	......	0.41	4.57	3.69	1.58	4.74	1.69	8.01	......	6.32	6.00	4.04	4.00	23 39	30 00
......	......	1.49	1.49	0.82	11.60	1.23	0.90	13 78	......	12.88	10.00	*3.13	1.00	21 14	21 00

* Potash largely, if not entirely, in form of sulfate. See page 88.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
B. F. Demarris & Son.—(Cont.)		
Potato Fertilizer	H. O. Newcomb	1042
Complete No. 1 Bone Phosphate	"	1043
J. H. Denise, Freehold, N. J.		
Grass Manure	H. D. Hance	1642
Special Potato	"	1643
Garden and Truck	"	1644
High-Grade Potato	"	1645
Corn Phosphate	"	1646
H. W. Doughten, Moorestown, N. J.		
Special Potato Manure	H. I. Budd	1070
Dried and Ground Fish Guano	"	1071
Sure Shot Superphosphate	"	1072
Runyon Field, Bound Brook, N. J.		
Cabbage Manure	H. S. Van Nuys	1166
Potato Manure	"	1184
J. C. Fifield Sons & Co., Bakersville, N. J.		
Special Potato and Cabbage	H. I. Budd	1283
Special Sweet Potato	J. C. Griscom	1125
Fish and Potash	C. Kraus	1544
Fithian & Pennell, Bridgeton, N. J.		
Complete Phosphate	H. O. Newcomb	1145
Geo. B. Forrester, New York City.		
Irish Potato Manure	F. E. Woodruff	1400
W. O. Garrison, Bridgeton, N. J.		
Gold Dust	H. O. Newcomb	1044
Fish Guano	"	1046
Pride of Cumberland	"	1048
Farmers' Pride	"	1049
XX Brand	J. H. Richardson	1474
Truckers' Pride	"	1461
J. C. Griscom, Woodbury, N. J.		
King Crab Compound	W. C. Smallwood	1127
Wyckoff Hendrickson, Allentown, N. J.		
High-Grade Potato Manure	J. M. Dalrymple	1235
Special Potato Manure	"	1237
Corn Manure	"	1359
S. M. Hess & Bro., Philadelphia, Pa.		
Potato and Truck Manure	F. E. Woodruff	1890
Keystone Bone Phosphate	"	1889

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	0.77	1.61	2.38	1.64	6.14	2.94	1.73	10.81	....	9.08	9.00	7.66	6.00	$23 97	$28 00
......	0.79	1.64	2.43	1.64	8.96	1.00	0.81	10.77	....	9.96	9.50	6.07	2.00	22 45	24 00
7.37	......	0.64	8.01	7.79	3 00	4.55	1.36	8.91	....	7.55	6.00	3.63	2.50	33 87	34 00
2.03	......	1.85	3.88	3.69	4.68	3.74	1.76	10.18	....	8.42	8.00	8.66	8.50	28 08	29 50
2.76	......	1.80	4.56	4.10	3.62	4.75	2.67	11.04	....	8.37	9.00	4.44	6.00	26 70	29 00
1.60	......	2.16	3.76	3.69	5.08	2.85	1.74	9.67	....	7.93	8.60	10.27	10.00	28 75	30 00
0.44	......	2.24	2.68	2.46	5.54	3.56	3.53	12.63	....	9.10	9.00	5.93	5.00	23 95	25 00
......	1.76	0.87	2.63	2.46	7.10	2.64	1.97	11.71	....	9.74	10.00	*7.38	7.00	25 73	29 00
......	......	3.58	3.58	3.69	3.86	1.74	1.55	7.15	....	5.60	5.85	5.09	3.00	22 01	28 00
0.85	....	1.85	2.70	2.87	7.96	2.42	2.51	12.89	11.00	10.38	10.00	3.01	3.00	22 24	27 00
1.31	0.21	2.33	3.85	4.10	0.16	8.32	4.16	12.64	....	8.48	8.00	7.67	7.00	28 48	31 00
1.02	0.92	1.29	3.23	3.28	0.02	4.75	1.84	6.61	....	4.77	8.00	8.90	7.00	23 11	28 00
......	......	2.49	2.49	2.46	2.90	4.27	2.87	10.04	....	7.17	7.00	7.70	7.00	22 84	33 00
......	......	2.11	2.11	2.05	1.51	5 19	2.70	9.43	....	6.73	6.00	9.74	10.00	22 84	35 00
......	......	2.49	2.49	1.64	4.28	3.73	1.92	9.93	....	8.01	7.00	4.20	4.00	20 32	29 00
0.26	......	1.52	1.78	1.64	6.88	1.52	2.10	10.50	....	8.40	8.00	2.09	2.00	16 61	23 50
1.85	1.89	0.03	3.77	3.69	5.20	1.60	1.81	8.61	....	6.80	5.50	9.43	10 00	27 06	33 00
0.26	......	0.75	1.01	0.82	4.56	4.31	1.77	10.64	10.00	8.87	9.00	3.03	2.50	15 29	17 00
1.24	......	1.55	2.79	4.10	5.92	2.44	1.76	10.12	....	8.36	8.00	6.63	8.00	23 12	30 00
1.10	......	0.73	1.83	2.05	3.28	6.06	3.84	13.18	....	9.34	9.00	3.26	3.00	19 07	25 00
0.75	......	0.83	1.58	1.64	5.00	5.01	3.17	13.18	....	10.01	9.00	1.93	2.00	17 68	25 00
......	......	1.46	1.46	1.23	3.52	3.20	2.51	9.23	7.00	6.72	6.00	2.27	2.50	14 32	20 00
0.81	......	3.11	3.92	4.10	5.60	1.97	1.07	8.64	....	7.57	8.00	7.37	7.00	26 48	33 00
0.79	1.24	1.90	3.93	4.10	6.16	2.56	0.79	9.51	10.00	8.72	8.00	5.14	6.00	25 79	31 00
1.61	0.21	2.09	3.91	2.46	3.52	4.58	1.00	9.10	....	8.10	8.00	10.64	10.00	29 43	32 00
1.17	......	2.02	3.19	1.64	3.62	4.22	1.57	9.41	....	7.84	7.00	10.66	10.00	27 27	29 00
......	......	1.80	1.80	1.64	7.18	4.04	3.83	15.05	....	11.22	8.00	4.88	4.00	22 66	25 00
0.80	......	1.67	2.67	2.46	6.40	1.94	1.98	10.32	....	8.34	8.00	6.70	6.00	23 04	35 00
......	......	0.92	0.92	0.82	5.84	2 24	2.60	10.68	10.00	8.08	8.00	1.64	1.00	13 45	28 00

* Potash largely, if not entirely, in form of sulfate. See page 38.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
S. M. Hess & Bro.—(Cont.)		
Special Potato	W. T. Woerner	1802
Special Corn	H. I. Budd	1618
Ira Hill, Copper Hill, N. J.		
Pure Bone Phosphate	A. Dilts	1413
Potato Phosphate	"	1414
Hill & Co., Flemington, N. J.		
No. 2 Bone Phosphate	A. Dilts	1416
Standard Bone Fertilizer	"	1417
10 Per Cent. Potato Phosphate	"	1418
Hires & Co., Quinton, N. J.		
Special Wheat and Oats Phosphate	W. Pettit	1256
Special Potato Manure	"	1258
Special Potato and Tomato Phosphate	"	1259
Standard Bone Phosphate	"	1260
International Seed Co., Rochester, N. Y.		
Potato and Truck Manure	S. Wood	1104
Grass and Grain	J. J. Mitchell	1524
Keystone Chemical Fertilizer Co., Philadelphia, Pa.		
Economizer Fertilizer	J. H. Richardson	1462
Special Potato	"	1463
Lister's Agricultural Chemical Works, Newark, N. J.		
Special Corn and Potato	H. O. Newcomb	1146
Potato Manure	J. B. Ward	1601
Potato No. 2	H. S. Van Nuys	1175
Standard Pure Bone Superphosphate of Lime	J. M. Dalrymple	1239
Ammoniated Dissolved Bone Phosphate	"	1240
U. S. Superphosphate	F. E. Woodruff	1395
"G" Brand	A. Dilts	1419
Fruit and Vine	J. B. Ward	1608
The Mapes Formula & Peruvian Guano Co., N. Y. City.		
Cereal Brand	A. Dilts	1421
Economical Potato Manure	J. Heck	1216
Corn Manure	J. B. Ward	1606
Lawn Top Dressing	"	1605
Complete Manure, "A" Brand	J. J. Mitchell	1526
Complete Manure for General Use	"	1528
Potato Manure	H. I. Budd	1284
General Crop Brand	J. M. Dalrymple	1483
Complete 10 Per Cent. Potash	D. N. Warbasse	1436

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.88	......	2.35	3.23	3.28	7.12	1.50	1.62	10.24	....	8.62	8.00	6.92	7.00	$25 15	$33 00
......	......	1.15	1.15	0.82	4.66	3.16	1 96	9.78	....	7.82	8.00	2.27	2.00	14 21	25 00
......	......	2.26	2.26	2.05	1.40	5.81	2.50	9.21	10.50	6.71	....	3.50	2.50	17 92	23 00
......	......	2.70	2.70	3.28	1.98	5.52	2.49	9.99	10.50	7.50	....	8.73	9.00	24 56	28 00
......	......	1.32	1.32	0.82	1.76	5.19	4.47	11.42	....	6.85	8.00	2.76	2.00	15 30	19 00
......	......	1.45	1.45	2.05	4.52	3.44	2.56	10.52	....	7.96	8.00	2.24	2.50	15 52	22 00
0.45	0.45	1.10	2.00	1.64	3.08	4.51	3.53	11.12	....	7.59	8.00	9.71	10.00	23 53	27 00
......	......	0.90	0.90	0.82	4.16	4.12	2.52	10.80	....	8.28	8.00	2.51	2.00	14 30	16 00
......	......	2.90	2.90	2.46	5.22	2.78	1.97	9.97	....	8.00	7.00	*9.72	10.00	26 74	29 00
......	......	2.36	2.36	2.46	7.80	0.51	1.20	9.51	....	8.31	8.00	5.40	5.00	20 93	23 00
......	......	1.84	1.84	1.64	7.80	1.75	1.14	10.69	....	9.55	9.00	3.71	3.00	19 05	20 00
0.41	......	0.91	1.32	1.23	5.06	2.79	2.11	9.96	9.00	7.85	8.00	7.29	7.00	18 94	28 00
......	......	2.01	2.01	1.64	6.30	3.17	4.18	13.60	11.00	9.47	10.00	2.06	2.00	19 30	25 00
0.78	......	0.99	1.77	1.76	5.64	2.86	1.87	9.37	9.50	8.00	8.50	*4.92	2.50	18 53	25 00
0.33	......	1.04	1.37	1.64	2.68	3.90	2.32	8.90	9.00	6.58	8.00	2.29	5.00	13 71	30 00
......	......	1.74	1.74	1.64	4.18	5.52	2.95	12.65	9.00	9.70	8.00	3.16	3.00	19 14	25 00
0.21	1.45	1.57	3.23	3.28	6.60	2.24	2.22	11.06	9.00	8.84	8.00	6.94	7.00	26 03	36 00
......	1.20	0.98	2.15	1.64	8.04	1.70	2.83	12.07	11.00	9.74	10.00	*5.89	4.00	23 06	26 00
......	0.97	1.48	2.45	2.46	7.72	2.88	3.49	14.09	11.00	10.60	9.00	2.29	2.00	21 85	25 00
......	0.22	1.77	1.99	1.64	6.10	3.87	2.90	12.87	9.00	9.97	8.00	1.92	1.00	19 16	22 00
......	0.21	0.99	1.20	1.03	5.46	3.03	2.46	10.95	9.00	8.49	8.00	2.78	2.00	15 89	20 25
......	......	0.96	0.96	0.82	5.76	2.43	2.48	10.67	10.00	8.19	8.00	4.09	4.00	15 72	19 00
......	0.23	2.60	2.83	1.64	1.02	7.89	3.30	12.21	....	8.81	8.00	6.73	7.00	25 03	32 00
1 07	......	1.32	2.39	1.64	1.70	6.02	0.53	8.25	8.00	7.72	6.00	3.61	3.00	18 22	28 00
1.89	......	1.32	3.21	3.28	2.00	5.06	0.71	7.77	6.00	7.06	4.00	*9.14	8.00	25 99	35 00
0.90	......	1.55	2.45	2.46	0.70	8.89	1.65	11.24	10.00	9.59	8.00	5.54	6.00	22 40	35 00
1.80	......	0.45	2.25	2.46	2.04	2.32	0.16	4.52	....	4.36	3.50	3.55	2.50	13 96	24 00
0.58	......	2.13	2.71	2.46	3.18	8.10	1.77	13.05	12.00	11.28	10.00	3.05	2.50	23 02	35 00
0.95	......	2.61	3.56	3.28	3.08	6.60	1.65	11.33	10.00	9.68	8.00	4.95	4.00	25 56	39 00
1.77	0.25	1.67	3.69	3.69	2.66	6.24	1.52	10.42	8.00	9.90	8.00	*8.47	6.00	26 79	39 00
0.32	......	1.42	1.74	1.64	2.38	6.62	0.90	9.90	10.00	9.00	8.00	*2.62	2.00	17 42	25 00
0.41	......	2.18	2.59	2.05	1.20	4.19	0.79	6.18	5.00	5.39	3.00	10.22	10.00	22 53	33 00
1.12	......	1.29	2.41	2.46	2.90	5.81	0.55	9.26	6.00	8.71	5.00	8.39	10.00	23 32	33 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
Hugh McAnany, Philadelphia, Pa.		
Quaker City Poudrette	H. O Newcomb	1006
Mixner & Mickel, Bridgeton, N. J.		
Special Mixture	H. O. Newcomb	1050
Top Dresser	"	1051
Complete	"	1052
High Grade	"	1053
Fish Mixture	"	1055
Monmouth Chemical Works, Shrewsbury, N. J.		
Potato Fertilizer	J. Healier	1653
Albert Nelson & Co., Allentown, N. J.		
Quick and Lasting Fertilizer for All Crops	J. M. Dalrymple	1362
Corn, Truck and Tomato Fertilizer	C. Burgmiller	1582
Special Potato	H. I. Budd	1621
Grass and Grain Special	H. Stryker	1665
Corn Fertilizer	"	*1666*
High-Grade Superphosphate	"	1667
Wm. C. Newport & Co., Willow Grove, Pa.		
Gilt Edge Potato Manure	H. I. Budd	1077
Farmers' Ammoniated Bone Phosphate	J. M. Dalrymple	1364
Fish, Bone and Potash	H. I. Budd	1076
No. 1 for Potatoes, Corn and Truck	H. O. Newcomb	1010
Evans' Brand, Potato Manure	W. T. Woerner	1305
Grain and Grass Special	H. O. Newcomb	1403
Rectified Phosphate	H. I. Budd	1073
High-Grade Potato Guano	"	1075
Potato Manure	"	1078
Dissolved Bone Phosphate	W. T. Woerner	1307
Potato and Truck Manure	W. O. Ward	1335
James E. Otis, Tuckerton, N. J.		
Special for Potatoes	J. C. Griscom	1128
Menhaden Fish Guano	H. I. Budd	1286
S. L. Pancoast, Mullica Hill, N. J.		
Early Potato Grower	J. C. Griscom	1130
Early Truck	"	1131
Peterson & Smith, Woodstown, N. J.		
Special Corn Mixture	W. Pettit	1255
Special Potato Mixture	"	1261
Wheat and Oats Superphosphate	"	1262
Potato and Tomato Superphosphate	"	1263
[illegible]	"	[illegible]

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total *Guaranteed.*	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.25	0.21	0.91	1.37	1.64	0.02	2.95	0.15	3.12	....	2.97	4.00	0.63	1.00	$7 87	$18 00
0.68	......	1.68	2.36	1.23	8.92	5.06	5.33	14.31	....	8.98	9.00	1.98	2.00	20 07	23 00
3.04	......	1.66	4.70	4.51	0.50	6.40	1.72	8.62	....	6.90	6.00	*10.64	9.50	30 87	33 00
0.34	.....	1.72	2.06	2.05	6.22	3.24	2.52	11.98	....	9.46	8.00	2.88	3.00	19 37	25 00
0.72	......	1.84	2.56	2.46	5.86	1.04	0.64	7.54	....	6.90	6.00	10.07	10.00	23 63	31 00
1.05	......	1.65	2.70	2.46	3.10	3.85	1.28	8.23	....	6.95	7.00	3.88	3.00	18 98	26 00
0.32	0.85	1.61	2.78	2.87	5.08	2.03	1.29	8.40	....	7.11	8.00	8.37	10.00	23 61	32 00
0.69	......	1.32	2.01	2.05	6.54	2.39	0.85	9.78	9.00	8.93	8.00	12.94	12.00	26 40	27 00
0.48	0.90	1.19	2.57	2.46	5.86	2.78	1.95	10.59	9.00	8.64	8.00	4.82	4.00	21 64	26 00
0.75	......	1.30	2.05	2.05	6.24	2.68	1.03	9.95	9.00	8.92	8.00	10.34	10.00	24 37	27 00
0.25	0.24	0.98	1.47	1.23	5.74	3.08	3.00	11.82	10.00	8.82	8.00	2.04	2.00	16 38	21 50
0.39	0.36	1.04	1.79	1.64	5.42	2.12	3.13	10.67	9.00	7.54	8.00	2.30	2.00	16 36	22 00
0.29	0.26	1.39	1.94	1.64	3.94	4.79	2.89	11.62	10.00	8.73	8.00	2.89	3.00	18 47	23 00
0.76	......	1.48	2.24	1.85	4.90	2.46	2.05	9.41	9.00	7.33	7.00	8.92	10.00	22 64	30 00
......	......	0.82	0.82	0.82	2.28	6.05	2.62	10.95	9.00	8.33	7.00	3.45	4.00	14 93	22 00
0.85	....	1.91	2.76	1.64	5.58	2.09	2.07	9.74	9.00	7.67	7.00	6.21	5.00	21 42	27 00
0.65	......	1.62	2.27	1.64	6.54	2.37	1.97	10.88	10.00	8.91	8.00	4.69	3.00	20 68	24 00
0.48	0.36	2.14	2.98	3.28	5.08	1.62	1.64	8.34	8.00	6.70	6.00	10.31	10.00	25 50	33 00
......	......	0.84	0.84	0.82	0.70	6.33	2.12	9.15	8.00	7.03	6.00	1.30	2.00	11 68	18 00
0.83	......	2.81	3.64	3.28	5.74	1.75	1.50	8.99	9.00	7.49	7.00	5.55	5.00	24 12	31 00
0.64	......	1.77	2.41	2.46	5.72	2.02	1.53	•9.27	....	7.74	8.00	8.86	10.00	23 33	30 00
0.70	......	2.09	2.79	3.28	5.02	1.65	1.67	8.34	....	6.67	6.00	*11.11	10.00	25 65	32 00
1.25	......	0.65	1.90	1.64	4.94	1.75	2.33	9.02	....	6.69	7.00	8.03	8.00	20 02	30 00
0.21	......	0.55	0.76	0.82	4.62	1.54	8.78	14.94	....	6.16	6.00	8.59	7.00	19 37	27 00
......	......	2.86	2.86	2.46	4.26	2.94	2.21	9.41	....	7.20	7.00	8.62	10.00	24 56	28 00
......	......	3.02	3.02	3.28	3.86	4.49	3.58	11.88	....	8.35	7.00	4.72	5.00	23 44	28 00
0.49	......	2 61	3.10	3.28	6 44	2.22	1.31	8.97	....	7.66	7.50	7.60	7.50	24 36	29 00
1.37	......	2.49	3.86	3.69	5.72	1.83	1.48	9.03	....	7.55	7.50	5.39	5.00	24 53	28 00
1.19	......	1.41	2.60	2.46	4.24	2.17	1.61	8.02	....	6.41	6.00	3.84	3.00	18 15	24 00
1.16	......	1.30	2.46	2.46	2.80	3.45	2.32	8.57	....	6.25	6.00	10.97	10.00	23 91	27 50
......	......	1.14	1.14	0.82	3.54	4.36	2.15	10.05	....	7.90	8.00	3.10	2.00	15 05	17 00
0.63	......	1.87	2.50	2.46	4.24	3.62	3.43	11.29	....	7.86	8.00	5.30	5.00	21 48	25 00
0.41		1.27	1.68	1.64	4.48	2.31	3.11	9.90		6.79	6.00	9.64	10.00	27 43	28 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
Enos Richmond, Elmer, N. J.		
Special Corn	W. O. Ward	1340
Edward Rigg, Jr., Burlington, N. J.		
Special Potato Fertilizer	H. I. Budd	1291
Fish Guano	"	1292
M. F. Riley, Elmer, N. J.		
Potato Fertilizer	W. Pettit	1265
Special for Wheat and Grass	"	1266
Complete Fertilizer	"	1267
High-Grade Potato	"	1268
Ruckmann Bros., New Brunswick, N. J.		
Potato Fertilizer	W. T. Woerner	1313
Corn Fertilizer	"	1314
Truck Fertilizer	"	1315
Grain Fertilizer	"	1316
Russell Agricultural Chemical Co., Newark, N. J.		
Potato Manure	H. S. Van Nuys	1034
Special Corn Fertilizer	"	1035
Ten Per Cent. Potato	W. T. Woerner	1310
Champion Manure	J. M. Dalrymple	1249
Two Tons in One	"	1484
Ammoniated Dissolved Bone Phosphate	A. Dilts	1426
Harvest Queen Phosphate	"	1424
Climax	"	1425
Special Potato Fertilizer	W. O. Ward	1331
Saul & Johnson, Erma, N. J.		
Anti-Trust Potato and Tomato Grower	J. H. Richardson	1470
Sharpless & Bro., Camden, N. J.		
Ten Per Cent	S. Wood	1108
No. 1	"	1109
Special Potato Manure	"	1110
Extra High-Grade Manure	"	1111
M. L. Shoemaker & Co., Philadelphia, Pa.		
Swift-Sure Superphosphate for General Use	J. M. Dalrymple	1368
" " " " Potatoes	J. H. Richardson	1468
" " Special 10 Per Cent. Potato Fertilizer	H. I. Budd	1626
" " " " " " " " No. 2	H. S. Van Nuys	1181
" " New Jersey Special	C. Kraus	1548
Guano for Tomatoes, Truck and Corn	A. Dilts	1459
Echo Superphosphate	D. N. Warbasse	1443

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	0.96	0.96	0.82	7.64	1.88	2.59	12.11	....	9.52	9.00	3.63	3.00	$16 71	$19 50
0.39	......	1.18	1.57	1.64	5.82	2.22	1.80	9.84	....	8.04	8.00	9.86	10.00	22 01	27 00
......	......	2.84	2.84	2.46	1.78	4.51	3.52	9.81	....	6.29	7.00	6.09	6.00	21 97	27 00
0.20	......	1.52	1.72	1.64	2.34	5.22	1.37	8.93	....	7.56	8.00	7.50	7.00	19 91	26 00
......	......	1.80	1.80	1.64	2.42	6.21	5.35	13.98	....	8.63	12.00	3.28	3.00	19 31	25 00
......	......	0.87	0.87	0.82	3.14	3.79	3.25	10.18	....	6.93	8.00	2.38	2.00	13 03	20 00
1.26	......	1.10	2.36	2.46	4.38	2.70	1.15	8.23	....	7.08	8.00	9.94	10.00	23 04	30 00
......	1.04	1.92	2.96	2.25	0.92	6.28	3.75	10.95	8.00	7.20	5.00	5.33	9.00	22 80	30 00
......	0.96	2.46	3.42	2.50	1.04	5.25	4.03	10.32	9.00	6.29	5.00	3.12	2.50	21 59	25 00
......	0.90	2.74	3.64	3.00	1.66	5.91	4.17	11.74	10.00	7.57	7.00	*5.04	5.00	25 64	28 00
......	0.87	2.45	3.32	2.50	1.90	5.71	3.46	11.07	9.00	7.61	5.00	4.35	5.00	23 40	24 00
1.63	0.28	1.31	3.22	3.70	2.96	3.69	4.62	11.27	8.50	6.65	7.50	6.59	7.00	23 77	28 00
......	0.28	1.92	2.20	1.65	2.50	3.85	4.76	11.11	9.00	6.35	8.00	2.82	3.00	17 71	20 00
......	......	1.29	1.29	1.64	4.72	3.72	3.11	11.55	9.00	8.44	8.00	9.91	10.00	22 23	30 00
......	......	0.72	0.72	0.82	5.02	2.86	3.82	11.70	9.00	7.88	8.00	2.07	2.00	13 47	21 00
......	......	2.13	2.13	2.05	4.78	5.47	8.94	19.19	20.00	10.25	....	3.35	2.50	23 50	24 00
......	......	1.86	1.86	1.80	5.34	2.77	2.71	10.82	11.00	8.11	9.00	1.80	1.50	16 67	24 00
......	......	1.13	1.13	1.23	5.08	4.15	2.37	11.60	11.50	9.23	9.50	2.24	2.00	15 70	23 00
......	......	0.86	0.86	0.82	4.84	3.40	4.06	12.30	9.00	8.24	8.00	2.02	2.00	14 33	20 00
......	......	1.27	1.27	1.64	5.20	3.38	3.72	12.30	9.00	8.58	8.00	3.04	3.00	16 71	25 00
......	0.22	2.17	2.39	2.46	....	9.75	3.12	12.87	....	9.75	7.00	7.75	7.00	25 26	28 00
1.81	......	3.26	5.07	8.20	6.55	1.21	1.06	7.83	....	6.77	4.00	5.97	4.00	27 77	45 00
0.69	......	1.89	2.58	1.64	6.70	2.28	1.89	10.87	....	8.98	8.00	5.38	3.00	22 29	24 00
0.44	1.01	1.29	2.74	2.05	5.78	2.63	1.27	9.68	....	8.41	7.00	8.25	10.00	24 62	28 00
0.60	......	2.24	2.84	3.28	5.46	1.94	1.87	9.27	....	7.40	6.00	8.99	10.00	24 64	30 00
1.15	......	1.71	2.86	2.46	6.60	3.83	3.82	14.25	14.00	10.43	9.00	6.44	4.00	26 12	32 00
0.87	......	1.64	2.51	2.46	6.50	4.18	3.12	13.75	11.00	10.63	8.00	7.40	6.50	25 86	32 00
1.44	......	2.24	3.68	3.28	3.44	4.29	2.32	10.05	....	7.73	6.00	10.87	10.00	29 10	28 00
0.72	......	1.55	2.27	2.05	4.82	4.24	3.49	12.55	....	9.06	8.00	10.74	10.00	26 57	32 00
......	......	1.53	1.53	1.03	5.00	5.65	3.90	14.55	....	10.65	8.00	2.25	2.00	19 02	24 00
0.64	......	1.59	2.23	1.64	3.26	6.08	4.22	13.56	....	9.34	8.00	5.64	6.00	22 70	26 00
......	......	1.64	1.64	1.23	4.82	5.44	4.88	15.14	9.00	10.26	7.00	2.06	1.50	19 21	24 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
M. L. Shoemaker & Co.—(Cont.)		
Good Enough Superphosphate	C. Kraus	1572
New Jersey Special for Oats	H. S. Van Nuys	1163
Lester Shurts, Neshanic, N. J.		
Standard Phosphate	H. S. Van Nuys	1349
L. W. Sickler, Glassboro, N. J.		
Special 10 Per Cent. Potato	J. C. Griscom	1132
Guano for Tomatoes	"	1133
Rufus W. Smith, Elmer, N. J.		
Ammoniated Consummate Fertilizer	W. Pettit	1269
Complete Bone Fertilizer	"	1270
High-Grade Trucker	"	1271
Somerset Chemical Co., Bound Brook, N. J.		
Excelsior Potato Manure	H. I. Budd	1079
Peerless Potato Manure	J. C. Griscom	1134
Sweet Potato and Tomato Manure	J. H. Richardson	1478
Royal Potato Grower	W. T. Woerner	1320
Reliance Phosphate	H. O. Newcomb	1155
Harvest Queen Phosphate	J. M. Dalrymple	1485
Special Potato Manure	H. O. Newcomb	1153
Stevens Bros., Cedarville, N. J.		
Special for Peas	H. O. Newcomb	1016
Henry Taylor, Vineland, N. J.		
No. 1 Special Potato Manure	H. O. Newcomb	1160
No. 2 " " "	"	1162
$25 Potato Manure	"	1161
The Taylor Provision Co., Trenton, N. J.		
High-Grade Corn and Truck	C. Kraus	1552
High-Grade Potato and Truck	C. H. Herbert	1508
Special Potato Fertilizer	"	1502
Corn Formula	J. M. Dalrymple	1585
A. D. B. Special Fertilizer	"	1371
I. P. Thomas & Son Co., Philadelphia, Pa.		
Special Sweet Potato Manure	J. C. Griscom	1136
Improved Superphosphate	A. Dilts	1427
Special High-Grade Potato Manure	J. M. Dalrymple	1236
Tip-Top Raw Bone Superphosphate	S. Wood	1594
Potato and Tomato Manure	H. O. Newcomb	1156
Vegetable Manure	D. N. Warbasse	1447

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.44	......	1.77	2.21	1.64	6.48	4.87	3.42	14.27	12.00	10.85	8.00	2.81	2.00	$21 60	$23 00
......	......	1.45	1.45	0.82	4.80	5.15	4.46	14.41	....	9.95	8.00	2.48	2.00	18 48	24 00
......	......	1.11	1.11	0.82	4.22	3.86	3.16	11.24	....	8.08	8.00	4.23	4.00	16 49	20 00
0.30	......	1.81	2.11	2.05	3.52	3.81	4.70	12.03	....	7.33	8.00	11.70	10.00	25 79	35 00
0.70	......	1.31	2.01	1.64	4.78	3.96	4.39	13.13	....	8.74	8.00	6.12	5.00	21 85	28 00
......	......	1.29	1.29	0.82	2.68	6.07	1.65	10.40	....	8.75	9.00	2.53	2.50	15 69	18 50
0.62	......	1 53	2.15	2.05	7.12	1.81	0.99	9.92	....	8.93	9.00	3.55	3.00	18 99	22 00
0.29	......	2.31	2.60	2.46	5.22	2.59	2.45	10.26	....	7.81	7.00	*7.33	7.00	23 74	26 00
0.49	0.33	1.12	1.94	2.46	....	5.81	2.78	8.58	....	5.80	8.00	10.33	10.00	21 73	30 00
0.73	......	2.11	2.84	3.28	....	5.70	2.65	8.35	....	5.70	7.00	8.79	9.00	23 01	30 00
......	0.23	1.83	2.06	1.64	0.06	9.69	6.02	15.77	....	9.75	8.00	11.51	12.00	28 56	30 00
0.45	......	1.25	1.70	1.64	....	5.03	2.58	7.61	....	5.03	7.00	10.69	10.00	20 40	28 00
0.32	0.20	1.27	1.79	2.05	0.08	5.85	1.95	7.88	....	5.93	6.00	4.33	4.00	16 01	23 00
......	......	0.84	0.84	0.82	0.08	8.66	1.97	10.71	....	8.74	10.00	5.37	4.00	16 79	25 00
0.38	0.22	1.38	1.98	1.64	....	7.88	6.13	14.01	....	7.88	8.00	5.70	5.00	21 39	28 00
2.49	......	1.11	3.60	3.69	5.68	2.27	1.87	9.82	....	7.95	6.00	5.88	5.00	24 22	32 00
......	......	1.31	1.31	1.65	5.00	2.15	1.85	9.00	....	7.15	7.00	7.05	10.00	18 07	27 00
......	......	1.67	1.67	1.64	6.00	2.26	1.52	9.78	....	8.26	8.00	10.20	10.00	22 88	27 00
......	......	1.18	1.18	1.23	3.64	2.83	1.83	8.30	....	6.47	6.00	5.42	5.00	15 58	25 00
0.95	......	1.59	2.54	2.46	6.70	3.10	2.64	12.44	....	9.80	10.00	4.83	5.00	22 71	23 35
1.74	......	1.25	2.99	2.87	4.54	2.51	3.69	10.74	12.00	7.05	....	10.70	10.00	26 50	32 00
0.68	......	1.41	2.09	2.05	5.86	3.33	2.46	11.55	....	9.19	8.00	10.08	10.00	25 15	29 50
1.17	......	1.45	2.62	1.23	4.04	4.03	3.38	11.45	....	8.07	8.00	12.40	12.50	27 88	30 00
......	......	1.35	1.35	1.23	6.12	4.08	5.71	15.86	....	10.15	8.00	5.69	5.00	21 58	24 50
0.71	......	0.99	1.70	1.64	3.92	3.41	1.82	9.15	8.00	7.33	7.00	10.08	10.00	21 79	28 00
......	......	0.86	0.86	0.82	8.64	2.39	0.94	11.97	12.00	11.03	10.00	*1.14	1.00	15 30	23 50
0.76	......	1.61	2.37	2.46	4.04	2.99	1.60	8.63	10.00	7.03	8.00	9.16	10.00	22 74	30 00
0.60	......	1.91	2.51	2.46	4.72	3.77	1.87	10.36	10.00	8.49	8.00	4.47	4.00	20 83	31 00
0.88	......	0.96	1.84	1.64	5.40	4.30	1.61	11.31	....	9.70	9.00	6.31	6.00	21 23	25 00
0.64	......	1.12	1.76	1.64	3.36	6.15	2.24	11.75	....	9.51	9.00	2.42	4.00	17 84	30 00

* Potash largely, if not entirely, in form of sulfate. See page 88.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
J. P. Thomas & Son Co.—(Cont.)		
Fish Guano	J. M. Dalrymple	1373
Farmers' Choice Bone Phosphate	"	1495
Wheat and Grass Compound	"	1496
Trenton Bone Fertilizer Co., Trenton, N. J.		
High-Grade Potato Fertilizer	J. M. Dalrymple	1229
Corn Mixture	"	1246
Special Mixture	"	1374
$32 Potato Manure	"	1375
Excelsior	"	1486
Special Potato	D. N. Warbasse	1448
Special 10 Per Cent. Potato, No. 2	"	1451
Superphosphate	H. I. Budd	1294
$25 Potato	W. T. Woerner	1322
Stults' Special Mixture	Station	1670
Grain Manure	"	1671
The J. E. Tygert Co., Philadelphia, Pa.		
Bone Phosphate	H. O. Newcomb	1059
Cabbage Manure	S. Wood	1113
Gold Edge Potato Guano	H. I. Budd	1627
Vineland Grain Co., Vineland, N. J.		
Potato Manure	H. O. Newcomb	1163
Warren Fertilizer Works, Belvidere, N. J.		
Wheat and Corn	D. N. Warbasse	1433
Geo. M. Wells, Moorestown, N. J.		
Prosperity Potato Manure	H. I. Budd	1080
Fish Guano	"	1081
High-Grade Potato Manure	"	1082
West Jersey Marl and Trans. Co., Woodbury, N. J.		
Our Mixture for All Crops	W. Pettit	1274
Special Potato Manure	J. C. Griscom	1137
Farmers' Friend	H. O. Newcomb	1024
High-Grade Truck Manure	"	1025
W. E. Whann, William Penn, Pa.		
Fish and Potash	H. I. Budd	1296
Chester Valley Special Potato and Truck	"	1298
No. 2 Ammoniated Superphosphate	H. O. Newcomb	[illegible]

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen. From Nitrates.	Nitrogen. From Ammonia Salts.	Nitrogen. From Organic Matter.	Nitrogen. Total Found.	Nitrogen. Total Guaranteed.	Phosphoric Acid. Soluble in Water.	Phosphoric Acid. Soluble in Ammonium Citrate.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Total Found.	Phosphoric Acid. Total Guaranteed.	Phosphoric Acid. Available. Found.	Phosphoric Acid. Available. Guaranteed.	Potash. Found.	Potash. Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	0.24	2.15	2.39	1.64	9.06	2.57	0.62	12.25	10.50	11.63	9.50	3.97	2.00	$22 93	$26 00
0.23	......	1.77	2.00	1.64	3.68	4.96	3.11	11.75	10.50	8.64	9.50	3.15	2.00	18 86	29 00
......	......	1.27	1.27	0.82	9.96	3.21	0.77	13.94	11.00	13.17	10.00	3.34	1.00	20 38	25 50
1.64	......	1.81	3.45	3.28	4.96	5.59	0.95	11.50	....	10.55	8.00	10.05	10.00	29 85	35 00
0.53	......	1.54	2.07	1.64	2.96	4.29	0.17	7.42	....	7.25	7.00	6.18	3.00	18 98	26 00
......	......	1.57	1.57	1.64	5.08	2.17	3.11	10.36	....	7.25	10.00	9.64	10.00	21 70	24 50
1.14	......	1.33	2.47	2.46	4.12	2.44	2.09	8.65	....	6.56	8.00	10.24	10.00	23 65	32 00
......	......	1.15	1.15	0.82	8.76	4.63	2.15	10.54	....	8.39	8.00	2.32	2.00	14 90	20 00
1.27	......	1.92	3.19	3.28	4.50	3.40	0.97	8.87	....	7.90	7.00	9.37	9.00	25 96	30 00
1.61	......	1.59	3.20	2.87	4.28	2.21	2.55	9.04	....	6.49	9.00	10.15	10.00	25 74	30 00
0.60	......	1.69	2.29	2.46	6.44	2.77	2.03	11.24	....	9.21	11.00	3.73	3.00	20 28	27 00
0.28	......	1.46	1.74	1.64	3.48	4.50	1.23	9.21	....	7.98	8.00	7.27	7.00	20 10	25 00
0.28	......	1.83	2.11	2.05	2.18	8.24	4.18	14.	....	10.42	11.00	10.26	10.00	27 45	32 00
......	......	2.07	2.07	1.64	2.86	4.08	2.71	9.60	....	6.89	8.00	3.12	3.00	17 24	22 00
0.28	......	1.26	1.54	1.85	7.82	1.60	2.46	11.88	11.00	9.42	9.00	2.46	2.50	17 30	25 00
1.02	......	1.35	2.37	2.46	5.80	1.44	1.81	9.05	8.50	7.24	7.00	4.14	5.00	18 66	35 00
......	......	1.47	1.47	1.64	4.62	2.11	2.64	9.37	8.00	6.73	7.00	5.65	5.00	17 28	28 00
......	0.86	1.17	2.03	1.64	10.02	0.89	0.01	10.92	....	10.91	7.00	*9.04	10.00	26 53	30 00
0.63	......	0.41	1.04	1.00	8.36	2.65	1.35	7.36	....	6.01	6.00	7.54	5.00	16 03	25 00
0.64	......	1.41	2.05	1.85	1.56	5.42	4.85	11.83	....	6.98	7.00	11.34	10.00	24 96	28 00
......	......	2.09	2.09	2.05	1.48	4.41	6.36	12.25	....	5.82	8.00	4.73	2.00	19 14	22 50
0.78	0.34	1.76	2.88	2.87	1.14	4.70	7.21	13.05	....	5.84	7.00	9.00	9.00	25 26	30 00
......	......	2.01	2.01	2.05	4.60	3.20	2.03	9.83	....	7.80	6.00	4.18	4.00	18 69	22 00
......	......	2.09	2.09	2.05	3.72	3.47	1.78	8.97	....	7.19	5.00	10.83	10.00	23 79	28 00
......	0.87	1.67	2.54	2.46	6.14	1.74	1.30	9.18	....	7.88	7.00	5.13	5.00	20 97	28 00
0.72	......	2.39	3.11	3.28	4.06	4.91	1.80	10.77	....	8.97	6.50	9.38	8.50	27 30	32 00
0.53	......	0.84	1.37	1.48	1.66	5.35	1.58	8.60	....	7.02	8.00	6.69	5.00	16 65	28 00
0.77	......	1.53	2.30	2.46	3.78	2.85	1.09	7.72	10.00	6.63	7.00	7.49	7.00	20 49	32 00
[illegible]	......	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
HOME MIXTURES.		
John S. Amerman, Neshanic, (No. 1)	H. S. Van Nuys	1353
" " (No. 2)	"	1352
H. H. Bell, Mount Ephraim	H. H. Bell	1090
Jos. Butterhof, Mullica Township	C. Kraus	1531
J. L. Schwickerath, Pomona	"	1554
H. Shirmer, Mullica Township	"	1530
David P. Voorhees, Hopewell	J. M. Dalrymple	1583
J. B. Warwick, Hartford	J. B. Warwick	1505
SPECIAL COMPOUNDS.		
Wm. C. Newport & Co., Willow Grove, Pa.		
Gloucester County Grange Fertilizer	J. T. Carter	0143
Moro Phillips Chemical Co., Philadelphia, Pa.		
Gloucester County Grange Sweet Potato	J. T. Carter	1003
M. L. Shoemaker & Co., Philadelphia, Pa.		
Pomona Grange Mixture No. 1	I. Miller	1668
" " " " 2	"	1669
The Taylor Provision Co., Trenton, N. J.		
Hagaman's Mixture	J. Hagaman	0182
Pomona Grange Grain Mixture	I. Miller	1226
" " Potato Mixture	"	1227
I. P. Thomas & Son Co., Philadelphia. Pa.		
Kerr's Mixture	J. R. Kerr	0180
Heath's Special Mixture	R. T. Heath	1199
Coopertown Farmers' Club, Improved Superphosphate	H. I. Budd	0138
" " " H. G. Potato Manure	"	0140
" " " Grain Special	"	0141
" " " Tip Top	"	0142
" " " Alkaline Bone	"	0139
Trenton Bone Fertilizer Co., Trenton, N. J.		
Voorhees Formula	S. T. Lewis	1140
Williams & Clark Fertilizer Co., New York City.		
Read's Potato Manure	W. O. Ward	1347
Bellemead Corn Fertilizer	P. A. Garretson	1663
" Potato Fertilizer	"	1664

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.74	......	2.07	2.81	......	2.38	3.34	1.13	6.85	....	5.72	....	4.65	....	$18 81	$25 00
0.50	......	1.39	1.89	......	3.36	4.84	2.20	10.40	....	8.20	....	2.13	....	16 74	20 00
0.73	0.48	0.93	2.14	......	2.10	3.43	0.99	6.52	....	5.53	....	5.01	....	16 79	....
0.95	......	1.09	2.04	......	5.78	1.83	2.60	10.21	....	7.61	....	8.04	....	21 53	20 80
1.86	......	1.73	3.59	......	2.54	7.27	7.80	17.61	....	9.81	....	4.49	....	27 60	....
......	0.60	1.96	2.56	......	3.14	3.83	2.26	9.23	....	6.97	....	6.98	....	21 20	23 43
......	......	1.64	1.64	......	2.36	9.81	0.78	12.95	....	12.17	....	15.12	....	30 58	32 00
0.70	1.10	1.38	3.18	......	0.20	13.06	4.08	17.34	....	13.26	....	9.49	....	33 57	....
0.62	1.12	1.83	3.57	3.49	4.86	2.65	2.46	9.97	10.50	7.51	6.00	9.61	8.75	27 96	26 85
......	0.22	1.83	2.05	2.05	2.52	6.22	3.78	12.52	11.00	8.74	6.00	11.04	10.00	26 22	23 90
1.01	......	1.12	2.13	2.05	2.14	5.71	4.40	12.25	....	7.85	8.00	6.99	6.00	21 96	21 50
......	......	1.34	1.34	0.82	5.68	4.08	3.67	13.43	....	9.76	9.00	5.18	3.00	19 92	16 50
......	......	0.84	0.84	0.82	2.68	3.78	3.36	9.82	....	6.46	9.00	5.55	5.00	†14 47	25 00
1.16	0.20	1.06	2.42	2.46	8.06	2.38	2.50	12.94	....	10.44	9.00	2.84	2.00	21 15	19 40
1.29	0.21	1.19	2.69	2.46	6.38	2.33	2.15	10.86	....	8.71	7.50	7.11	8.00	23 72	24 60
......	......	1.49	1.49	......	4.98	6.18	4.67	15.83	....	11.16	....	1.42	....	†17 74	25 00
......	0.81	0.66	1.47	0.63	4.02	5.94	2.88	12.84	....	9.96	10.00	*2.85	2.00	18 74	20 00
......	......	1.52	1.52	0.82	13.12	0.75	0.41	14.28	....	13.87	10.00	*2.87	1.00	21 76	25 00
......	2.99	1.15	4.14	2.46	8.58	0.93	0.22	9.73	....	9.51	8.00	*10.77	10.00	33 92	33 00
......	1.15	0.81	1.96	0.82	10.70	1.77	1.05	13.52	....	12.47	7.00	*2.49	1.00	21 77	23 00
......	1.68	2.04	3.72	2.46	9.70	1.01	0.68	11.39	....	10.71	8.00	*5.78	4.00	28 83	32 00
......	......	......	......	......	13.98	1.14	0.27	15.39	....	15.12	10.00	*2.81	2.00	18 04	20 00
0.96	......	3.07	4.03	......	4.20	4.97	1.97	11.14	....	9.17	....	*10.15	....	32 13	37 00
0.84	0.57	1.78	2.64	......	4.74	2.55	1.79	9.08	....	7.29	....	11.56	....	26 21	22 25
0.89	......	*1.04*	*1.43*	*1.23*	*2.62*	*4.80*	*3.46*	*10.88*	*7.00*	*7.42*	*6.00*	*5.38*	*5.00*	*17 79*	*18 50*
0.74	0.54	1.68	2.96	3.28	3.16	5.35	3.02	11.53	9.00	8.51	8.00	6.42	7.00	24 41	26 50

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

Station Number.	BRAND.	MANUFACTURER.
1193	Ground Bone	American Agricultural Chemical Co., N. Y. City
0127	*Pure Bone Meal (Williams & Clark)	" " " " " "
1509	Bone Meal	Armour Fertilizer Works, Chicago, Ill
1510	Pure Ground Bone	Allentown Manufacturing Co., Allentown, Pa
1877	Raw Bone	The Berg Co., Philadelphia, Pa
1096	Market Bone	Bowker Fertilizer Co., Boston, Mass
1595	Fresh Ground Bone	" " " " "
1066	Steamed Bone, No. 1	J. S. Collins & Son, Moorestown, N. J
1067	Steamed Bone, No. 2	" " " " "
1402	Pure Bone Dust	Peter Cooper's Glue Factory, New York City
1415	Pure Ground Bone	Ira Hill, Copper Hill, N. J
1257	Pure Ground Bone	Hires & Co., Quinton, N. J
1527	Pure Ground Bone	The Mapes Formula & Peruvian Guano Co., N.Y. City
1404	Pure Raw Bone Meal	Wm. C. Newport & Co., Willow Grove, Pa
1317	Ground Bone	Ruckmann Bros., New Brunswick, N. J
1444	Swift-Sure Bone Meal	M. L. Shoemaker & Co., Philadelphia, Pa
1870	Pure Bone	Somerset Chemical Co., Bound Brook, N. J
1112	Pure Bone Meal	Swift & Co., Chicago, Ill
0125	*Fine Ground Bone	I. P. Thomas & Son Co., Philadelphia, Pa
0135	*Slaughter-House Bone	" " " " " "
1490	Pure Ground Animal Bone	" " " " " "
1020	Button Bone Dust	Emil Wahl, Philadelphia, Pa
1435	Ground Bone	Warren Fertilizer Works, Belvidere, N. J
1023	Pure Bone Meal	West Jersey Marl and Trans. Co., Woodbury, N. J
1580	Bone Sawings	Winterbottom, Carter & Co., Egg Harbor City, N. J

* Samples of 1900, received too late for last bulletin. Valued by 1900 Schedule.

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

SAMPLER.	Station Number.	Mechanical Analysis. Finer than 1-50th in.	Mechanical Analysis. Coarser than 1-50th in.	Chemical Analysis. Nitrogen.	Chemical Analysis. Phosphoric Acid.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
J. W. Pincus	1193	60	40	2.20	28.42	$26 79	$21 50
W. W. Bodine	0127	55	45	2.90	23.58	24 57	23 25
J. J. Mitchell	1199	61	39	3.21	25.74	27 85	35 00
"	1510	53	47	3.90	21.88	26 46	32 00
F. E. Woodruff	1377	37	63	3.80	22.92	25 69	31 50
S. Wood	1096	44	56	1.86	26.72	23 51	35 00
J. B. Ward	1595	31	69	2.45	25.16	23 16	32 00
H. I. Budd	1066	56	44	1.77	27.98	24 95	25 00
"	1067	75	25	2.79	24.92	27 06	23 00
H. O. Newcomb	1402	55	45	1.45	28.70	24 50	22 00
A. Dilts	1415	51	49	3.84	20.96	25 49	27 00
W. Pettit	1257	70	30	2.28	27.66	27 22	26 00
J. J. Mitchell	1527	36	64	3.04	17.50	19 93	35 00
H. O. Newcomb	1404	34	66	3.93	23.98	26 53	28 00
W. T. Woerner	1317	42	58	3.75	22.88	25 92	25 00
D. N. Warbasse	1444	46	54	5.38	23.18	30 92	33 00
J. M. Dalrymple	1370	50	50	3.84	20.00	24 75	27 00
S. Wood	1112	83	17	2.75	25.62	28 06	23 00
Wm. Dubon	0125	44	56	2.87	16.86	19 05	....
J. Q. Holcombe	0135	53	47	1.15	17.26	15 35	21 35
J. M. Dalrymple	1490	50	50	3.31	23.28	25 56	32 00
H. O. Newcomb	1020	67	33	3.14	23.86	26 73	29 00
D. N. Warbasse	1485	14	86	3.91	22.96	24 24	28 00
H. O. Newcomb	1023	50	50	3.97	21.42	26 12	30 00
C. Kraus	1580	90	10	3.80	26.60	32 60	30 00

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

MANUFACTURER AND BRAND.	SAMPLER.	Station Number.
American Agricultural Chemical Co., New York City.		
Bradley's Alkaline Bone with Potash	J. J. Mitchell	1519
Read's Alkaline Bone	A. Dilts	1422
Susquehanna Soluble Bone Phosphate	W. O. Ward	1346
Armour's Fertilizer Works, Chicago, Ill.		
Dissolved Bone	J. J. Mitchell	1509
Bowker Fertilizer Co., Boston, Mass.		
Superphosphate with Potash	W. O. Ward	1329
E. Frank Coe Co., New York City.		
High-Grade Dissolved Bone and Potash	H. I. Budd	1061
Lister's Agricultural Chemical Works, Newark, N. J.		
Celebrated Ground Bone Acidulated	F. E. Woodruff	1393
The Mapes Formula and Peruvian Guano Co., New York City.		
Ammoniated Dissolved Bone	J. B. Ward	1604
Mixner & Mickel, Bridgeton, N. J.		
Phosphate and Potash	H. O. Newcomb	1054
Wm. C. Newport & Co., Willow Grove, Pa.		
Soluble Bone and Potash Phosphate	J. M. Dalrymple	1247
Ruckmann Bros., New Brunswick, N. J.		
Flesh and Bone	W. T. Woerner	1318
M. L. Shoemaker & Co., Philadelphia, Pa.		
Swift Sure Dissolved Bone	C. Kraus	1549
Lester Shurts, Neshanic, N. J.		
Corn Special	H. S. Van Nuys	1351
Somerset Chemical Co., Bound Brook, N. J.		
Degelatinized Bone	H. O. Newcomb	1151
I. P. Thomas & Son Co., Philadelphia, Pa.		
Alkaline Bone	A. Dilts	1428
Improved Animal Bone	J. M. Dalrymple	1493
Trenton Bone Fertilizer Co., Trenton, N. J.		
Corn Special	D. N. Warbasse	1449
Wool Waste	S. Wood	1114
" "	"	1592
" "	"	1598
Snuff Sand	C. H. Herbert	1504

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	......	......	......	3.90	6.46	3.31	12.67	11.00	9.36	10.00	1.96	1.00	$12 35	$20 00
......	......	......	......	......	5.52	4.44	3.18	13.14	12.00	9.96	10.00	1.88	2.00	12 83	16 00
......	......	......	......	......	13.06	2.73	1.10	16.89	15.00	15.79	14.00	......	......	*7.9	25 00
......	......	2.65	2.65	1.64	8.18	7.87	0.98	16.98	......	16.00	11.00	......	......	24 87	32 00
......	......	......	......	......	4.28	5.93	2.87	13.08	12.00	10.21	10.00	1.17	1.00	12 36	18 00
......	......	......	......	......	5.80	3.88	4.11	13.29	12.50	9.18	10.50	2.32	2.00	12 79	24 00
......	0.38	2.97	3.35	2.67	......	6.21	9.17	15.38	12.00	6.21	......	......	......	20 63	27 00
......	......	1.57	1.57	1.23	1.84	8.11	2.02	11.97	12.00	9.96	10.00	2.40	1.50	17 82	52 0(
......	......	......	......	......	6.86	3.98	2.08	12.92	......	10.84	10.00	1.95	2.00	13 33	16 0(
......	......	......	......	......	0.78	5.20	2.17	8.15	10.00	6.98	8.00	3.00	3.00	9 40	......
......	0.61	3.15	3.76	2.75	1.02	5.98	9.79	16.79	10.00	7.00	6.00	......	......	23 01	20 0(
......	......	2.20	2.20	1.64	8.30	4.93	6.55	19.78	13.00	13.23	10.00	......	......	22 89	28 3
......	......	......	......	......	8.34	5.52	1.48	15.34	......	13.86	12.00	3.38	3.00	17 32	16 0
......	0.69	0.51	1.20	1.23	......	14.20	13.02	27.22	28.00	14.20	15.00	......	......	23 32	25 0
......	......	......	......	......	3.18	7.70	0.93	11.81	12.00	10.88	10.00	2.67	2.00	13 52	19 0
......	......	1.32	1.32	1.64	4.14	8.25	9.51	21.90	20.00	12.39	12.00	......	......	20 41	26 0
0.28	......	3.44	3.72	4.10	7.94	3.38	1.93	13.25	......	11.32	9.00	......	......	23 88	32 (
......	......	2.34	2.34	......	......	......	......	0.55	......	......	......	1.21	......	......	2 (
......	......	2.31	2.31	......	......	......	......	0.52	......	......	......	3.12	......	......	2 5
......	......	2.47	2.47	......	......	......	......	0.44	......	......	......	2.29	......	......	2 5
		1.08	1.08		......	......	......	0.36	......	......	......	1.09	......	......	......

Sundry Materials.

0133. Canada Wood Ashes. Made by F. R. Lalor, Dunville, Ontario, Canada. Sent by C. M. Randolph, Bound Brook.

1084. Wood Ashes. Made by The Tyler-Hall Chemical Co., Readburn, N. Y. Sent by Stephen Roy, Glenwood.

1141. Canada Wood Ashes. Made by F. E. Hancock, Walkerton, Ontario, Canada. Sent by Wm. M. Brown, Cedarville.

1197. Canada Wood Ashes. Made by F. E. Hancock, Walkerton, Ontario, Canada. Sent by John Scullin, Hammonton.

1304. Canada Wood Ashes. Made by G. L. Munroe, Oswego, N. Y. Sent by P. G. Staats, Bound Brook.

1382. Wood Ashes. Made by Bowker Fertilizer Co., Boston, Mass. Sent by A. M. Griffen, Plainfield.

1407. Canada Wood Ashes. Sent by H. O. Newcomb, Cedarville.

1672. Wood Ashes. Made by Bowker Fertilizer Co., Boston, Mass. Sent by P. G. Staats, Bound Brook.

1673. Wood Ashes. Made by Bowker Fertilizer Co., Boston, Mass. Sent by P. G. Staats, Bound Brook.

	0133	1084	1141	1197	1304	1382	1407	1672	1673
	%	%	%	%	%	%	%	%	%
Phosphoric Acid	1.77	1.75	1.31	1.42	1.49	1.59	1.47	1.65	1.50
Potash	2.77	1.71	3.94	4.33	5.58	6.76	6.21	6.84	5.40
Lime	31.50	28.97	28.06	33.16	34.78	33.73	33.14	34.87	31.16
Valuation per ton	$4.19	$3.11	$4.99	$5.47	$6.77	$8.03	$7.39	$8.08	$6.60
Selling price per ton	9.00	8.00	10.75	12.00	10.50	......	11.00	10.50	10.50

0144, 0145, 0146, 0147. Marl. Sent by M. Crine, Morganville, N. J. It represents a total deposit of 500,000 tons, and the samples are taken from three local deposits, being respectively, upper part of No. 1, lower part of No. 1, No. 2 and No. 3. Selling price, 15 cents per ton.

0148. Marl. Sold by West Jersey Marl and Transportation Co., Woodbury, N. J. Sample taken from deposit near Sewell, N. J., and sent by J. M. Moore, Clayton.

	0144	0145	0146	0147	0148
Phosphoric Acid	1.54	1.06	0.94	0.95	1.44
Total Potash	1.68	1.01	1.43	1.28	1.81
Lime	1.70	4.11	0.87	0.46	1.58

0149. Garbage Refuse. Made by James Ross, Trenton, N. J. Sent by C. H. Cook, Trenton, N. J. Selling price, $2 per ton. It contains 2.07 per cent. phosphoric acid, 1.17 per cent. potash and 7.92 per cent. lime.

1004. Lime. Sent by M. F. Gano, Annandale, N. J. It contains 53.17 per cent. calcium oxid.

Appendix.

Station Number.	MANUFACTURER AND BRAND.	SAMPLER.
	B. F. Demarris & Son, Cedarville, N. J.	
1038	Fish Guano	H. O. Newcomb
	Wyckoff Hendrickson, Allentown, N. J.	
1360	Special Grain Manure	J. M. Dalrymple
	Frank Maul, Greenwich, N. J.	
1147	Grain Manure	H. O. Newcomb
	John E. Minch, Bridgeton, N. J.	
1148	Complete Phosphate	H. O. Newcomb
	Vineland Grain Co., Vineland, N. J.	
1164	Bone Phosphate	H. O. Newcomb
	Wm. C. Newport & Co., Willow Grove, Pa.	
1139	Evans Brand, Potato Manure	S. T. Lewis

Station Number.	Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.
											Available.				
	From Nitrates.	**From Ammonia Salts.**	**From Organic Matter.**	**Total Found.**	**Total Guaranteed.**	**Soluble in Water.**	**Soluble in Ammonium Citrate.**	**Insoluble.**	**Total Found.**	**Total Guaranteed.**	**Found.**	**Guaranteed.**	**Found.**	**Guaranteed.**	
1038	.....	1.22	2.09	3.31	2.46	8.20	0.84	0.80	9.84	....	9.04	7.50	7.27	2.00	$26 26
1360	1.52	......	1.61	3.13	1.23	5.94	3.22	2.24	11.40	....	9.16	8.00	5.43	3.00	24 09
1147	......	1.05	0.79	1.84	0.82	10.38	1.66	0.89	12.93	....	12.04	7.00	*2.92	1.00	21 32
1148	0.36	......	1.24	1.60	2.05	11.76	0.50	0.17	12.43	....	12.26	9.00	*6.76	2.50	23 67
1164	......	......	1.13	1.13	1.03	10.16	1.86	0.66	12.68	....	12.02	8.50	*6.67	1.50	21 73
1139	0.76	......	1.29	2.05	3.28	5.78	1.66	1.71	9.18	8.00	7.44	6.00	9.34	10.00	22 32

* Potash largely, if not entirely, in form of sulfate. See page 38.

FODDERS AND FEEDS.

I.

CONCENTRATED FEEDING STUFFS.

Introduction.

The Legislature of the State of New Jersey, on March 15th, 1900, passed a law regulating the sale of feeding stuffs in the State in much the same manner as the sale of fertilizing materials has been regulated for the quarter-century past. A copy of the full text of this law will be sent to anyone interested, upon application. Briefly stated, the law requires—

1. That every lot or parcel of certain concentrated feeding stuffs (for domestic animals), sold in this State shall have affixed thereto, in a conspicuous place on the outside, a printed statement of—

The number of net pounds contained.
The name or trade-mark of the material.
The name of the manufacturer or shipper.
The percentage of protein contained, and the percentage of fat contained.

If the feeding stuff is sold in bulk, or in packages belonging to the purchaser, this statement shall be furnished by the agent or dealer to the purchaser.

2. A certified copy of this statement shall be filed with the Director of the Experiment Station in the month of November of each year, accompanied, when requested, by a sample of the goods.

3. The feeding stuffs which are required to conform with these provisions of the law include—

Brewers' grains, dried,
Cerealine feeds,
Cocoanut meals,
Corn and oat chop,
Cottonseed meals,
Gluten meals,
Hominy feeds,
Linseed meals,
Maize feeds,
Malt sprouts,
Meat scrap, ground,
Mixed feeds,
Oat feeds,
Pea meals,
Rice meals,
Sugar feeds,
Starch feeds,
And all similar material.

4. The following feeding stuffs are exempted from the requirements of the law :

All kinds of hay and straw.

The whole seeds of wheat, barley, rye, oats, Indian corn, buckwheat and broom corn, and the unmixed meals made from the entire grains of any of these.

The meals made from pure grains ground together.

The brans and middlings of wheat, rye and buckwheat, when separate and unmixed with any other substances.

5. Should any of these materials, otherwise exempt, be mixed or adulterated with any substance for the purpose of sale, the package which contains it, or in which it is offered for sale, must have plainly marked or indicated thereon the true composition of the mixture, or the character of the adulteration.

6. The Experiment Station is authorized to have collected samples of every kind of material used in the feeding of domestic animals, to analyse them and to publish the results. Penalties, varying from $25 to $200, are provided for violations of the law.

The Reasons for the Law.

The reasons for a State control of feeding stuffs are much the same as for the control of fertilizers, to which it is analogous. As, formerly, the agriculturist depended upon his farm stock alone for his fertilizing material, but at this later date is taught by principle and practice to supplement the same by the purchase of commercial fertilizers, so in like manner the dairyman formerly depended upon his farm alone for his cattle food, but later has come to the use of supplementary materials. There are sound scientific principles for this development of practice, and as they have become more generally known and practiced, the use of concentrated feeding stuffs has increased, as was the case with fertilizers. And, as with fertilizers, so with feeds is it the case that a multiplicity of materials are offered to catch the dairyman's favor, with new ones appearing almost every day.

The greater part of these feeds, which are offered to draw the farmer away from the brans and middlings and meals of his local miller, are secondary, or by-products from the manufacture of other products primarily for the use of man. Thus linseed meal is the residue from the manufacture of linseed oil, the use of which in the arts is well

known. In like manner, we have the cottonseed meal from the cotton industry, gluten meal from the starch, and also from the glucose industry, cerealine feed, hominy feed, oat feed, etc., from the manufacture of what, as a class, has come to be called "breakfast foods," and other by-products from other processes of manufacture.

The first intention and main purpose of the manufacturer being to produce the linseed oil, or the starch, or the glucose, etc., it was but natural that the secondary products, which were offered as food for cattle, should not in many cases receive the care that would insure a uniform product of the highest degree of purity. For example, gluten meal at times would be the pure glutinous portion of the corn kernel, and at other times would have more or less of the bran and other portions of the corn mixed with it. Cottonseed meals in most instances have been the pure meat of the cottonseed, ground after cooking, and pressing out the oil, but in not a few instances have the hulls been included, thus reducing the value of the product by one-half, without considering the disadvantage of the presence of the indigestible hulls.

Besides this lack of care in keeping the side product in the highest degree of purity, or at least uniformity, the fact of a large number of factories putting out the same, or similar products, has led to further confusion, for as their processes may differ or undergo alteration, so will their side products. For example, there is a difference in the linseed meal (sometimes called "cake meal" and "oil meal"), made in the extraction or new process, and that made in the old process by pressure, whereas the main product of the factory—the linseed oil—is essentially the same by the two processes. So with the various by-products put on the market under the brand name of gluten meal. The same name has been used to designate materials varying widely in their composition, including both the true gluten meals and also the less nitrogenous forms, which are variously termed gluten feed, sugar feed, starch feed, etc. Oat feeds, also, include under the one designation feeds of considerable variability.

In addition to these considerations, there is the possibility of actual intentional adulteration to be guarded against, and there is no limit to which it may be carried. Our neighboring States have taken notice of this condition of affairs, and have passed laws similar to this in New Jersey, whereby it is required that this class of goods be guaranteed, and it be seen to that the guarantees are fulfilled. Without such a law as this in New Jersey also, it would be the most natural thing to expect that manufacturers having on hand two

batches of feed, the one superior to the other, would send the better to the locality where such goods are scrutinized and the poorer to the State where they are not.

For our own protection as a State, therefore, and for the protection of our cattle and horse feeders, it is necessary to have such a law in operation as has been outlined in the opening of this section. And not only for the protection of our feeders will this law operate, but also for the protection of our local millers, who are putting on the market the very highest grades of home-grown products, honestly made. There is no question but that they will be benefited by a clear exposition of the character of many of these feeds, which come, as novelties, into competition with the old-established line.

No manufacturer, however, whether local or in another section of our country, who is conducting his business in an open and above-board manner and selling his goods on their merits, can fail to be benefited by a law which places all goods upon a fair basis, for, by the operation of this law, all goods are brought to the attention of the consumer and their merits clearly portrayed. Analysis shows which are the better adapted for the purpose in hand; the consumer thereby is enabled to purchase with understanding, and apply his purchased material to the use to which they are best adapted, whether for milk, butter, flesh, work or maintenance, or as supplements to rations intended for these purposes. Misapplication of valuable feeds is thereby reduced to a minimum, and from their use results the maximum of profit. Confidence in the material, and ability to purchase further is thus established, which it is not likely would be the case had it been used without knowledge of its character. The rational consumption of feeds of all classes is consequently increased with profit to both producer and consumer.

To the feeder will this work prove of exceptional value, since it will direct his notice to many new and valuable sources of supply. To the local miller will it prove no disadvantage, for the mills are few which *can* supply the demand for bran and kindred old line products, without purchasing outside, and hence should the demand for these decrease through the use of the newer forms of feeds, all that would be necessary would be to meet the conditions by handling the new feeds; and to the manufacturers of these new feeds will it prove anything but a disadvantage, since that time can be devoted to making the very best product of which their plant is capable, which would otherwise be devoted to watching and meeting their competitors.

Sampling and Analyses.

Early in the fall of 1900 the Experiment Station made ready to carry out the provisions of the law. Copies of the latter, with an explanatory circular, were sent to all the millers and dealers in feeds so far as their names and addresses could be secured. In many cases these elicited requests for further information as to the liability of particular individuals, or in the case of particular kinds of feeding stuffs, all of which information the Station cheerfully afforded so far as lay in its power. In accordance with that section of the law requiring the same (see paragraph 2 of the abstract of the law at the beginning of this section), manufacturers or dealers quite generally furnished a certified copy of the statements which would accompany their goods in their sale, and several sent in addition sealed samples of the goods themselves, although this is not required unless the Experiment Station requests it.

Mr. D. N. Warbasse, of Newton, was appointed Deputy Collector of samples, and armed with the necessary bottles, shipping cases and other paraphernalia, proceeded to scour the State until interrupted by serious illness, when the work was continued by a member of the Station staff working in connection with his other duties. The entire State, therefore, has not received an equally thorough inspection. Nevertheless, 20 of the 21 counties were visited and 529 samples collected. Of these, 60—all duplicates, and further duplication being unnecessary—have been discarded and 469 have been analyzed, yielding the results which appear in tabulated form upon subsequent pages. The character of these samples, the number of each kind received, and the number analysed, are shown in the following table:

Feeds Received and Analyzed.

	Rec'd.	Ana-l'd.
American Calf Meal	2	2
" Poultry Food	3	2
Animal Meal, Meat, etc	7	5
Banner Stock Food	2	1
Barley Meal	1	1
Baum's Horse and Stock Food	1	1
Blatchford's Calf Meal	4	3
Brewers' Grains, dried	17	15
Cerealine Feeds	10	8
Chester Stock Food	10	10
Clover Meal	*1*	*1*
Cob Meal (Corn Ear Meal)	11	11
Corn and Oats	36	32
Cottonseed Meal	37	37
Dairy Feeds, miscellaneous	6	6
De Fi Corn and Oat Feed	1	1
Durham Corn and Oat Feed	1	1
Flaxseed Meal	7	7
Friends' Concentrated Dairy Feed	4	4
Germ Oil Meal	4	4
Gluten Feed, Buffalo	25	16
" Davenport	3	3
" Marshalltown	1	1
" *Nation'l Starch*	7	7
" Rockford Diamond	4	4
" Waukegan	1	1
Gluten Feed, miscellaneous	2	2
Gluten Meal, Chicago	7	6
H. O. Dairy Feed	6	5
" Horse Feed	10	8
" Poultry Feed	10	7
" Scratching Feed	2	2
Hominy Meal or Feed	24	20
Horse Feeds	52	49
Linseed Meals	74	68
Maizeline	1	1
Malt Sprouts	25	23
Poultry Feeds, miscellaneous,	5	5
Quaker Dairy Feed	12	8
Rice Feed	2	2
Royal Feed	2	2
Rye Bran	1	1
" Feed	1	1
" Middlings	1	1
Schumacher Stock Feed	3	2
Sucrene Dairy Feed	1	1
Star Chop	1	1
Sugar Beet Feed	1	1
Sugar Feed (Corn Bran)	15	12
Victor Corn and Oat Feed	15	12
Vim Oat Feed	6	6
Wheat Bran and Ship Stuff	18	18
Wheat Feeds	9	7
Unclassified	17	14

The analyses of these samples were made according to law by the methods of the Association of Official Agricultural Chemists, and included the determination of protein and fat (ether extract), and, in some cases, of fiber or other constituents, as the circumstances in the case seemed to warrant.

Classification of Feeds.

A study of the feeds which have been analysed will make it apparent that they should be separated into two classes, widely different in analysis in their extremes, and yet so approaching each other in character as to present no sharp dividing line where we shall say one class ends and the other class begins. The distinguishing feature of these two classes consists in the content of protein, which is commonly called the flesh-forming constituent of food, and which is similar to the white of egg and the gluten of wheat. Feeds containing considerable of this nutrient may, therefore, be called *protein feeds*, of which cottonseed meal, linseed meal and the gluten meals may be mentioned as examples. These feeds are purchased for the express purpose of improving the ration by the addition of protein, when the feeds and fodder on hand are low in that constituent.

The latter class of feeds, being low in their content of protein, are consequently high in the other constituents which are called the carbohydrates, of which sugar and starch are the purest examples. Feeds consisting, in greater part, of the carbohydrates may, therefore, be called *carbohydrate feeds*, and of these corn meal is probably the best example. Materials of this nature are not suitable additions to the feeding materials usually raised on the farm, since they themselves require the addition of protein feeds the same as the farm products do. Farmers usually have an abundance of carbohydrate feed on hand, and hence these feeds appeal to the city feeders of horses or stall-fed cattle.

The analyses of the feeds which have been examined are, therefore, tabulated so as to separate them into the (1) Protein Feeds, and (2) Carbohydrate Feeds. To this there is added (3) Feeds Made from Whole Grains, Ground Together, and (4) Poultry Food and Stock and Condimental Foods. The classification in detail, showing the average percentages of protein, fat and, in some cases, fiber, and the average selling prices per ton reported is to be found on the next page, after which follow the analyses of the individual samples in detail.

The Average Analyses and Price of Feeds Examined in 1901.

I. Protein Feeds.

	Protein.	Fat.	Fiber.	Selling Price.
Cottonseed Meal	45.71	9.48	......	$28 70
Chicago Gluten Meal	37.60	3.91	......	26 08
Linseed Meal	33.30	7.49	......	34 08
Flaxseed Meal	24.58	37.40	......	....
Marshalltown Gluten Feed	29.20	3.44	......	22 00
Rockford Diamond Gluten Feed	27.32	3.34	......	21 10
Buffalo Gluten Feed	26.51	3.60	......	21 87
Waukegan Gluten Feed	26.36	4.34	......	21 50
National Starch Co.'s Gluten Feed	25.88	3.96	......	21 86
Malt Sprouts	25.59	2.59	......	17 50
Dried Brewers' Grains	25.57	7.74	......	19 06
Davenport Gluten Feed	24.39	3.75	......	20 70
Sucrene Dairy Feed	21.75	6.90	8.96	21 00
H. O. Dairy Feed	18.42	3.85	12.75	22 70
Hoosier Mill Feed	18.39	4.70	7.07	20 00
Rankin's Wheat Feed	17.29	4.37	5.86	19 00
Buckeye Feed	17.13	4.49	5.94	20 33
Ship Stuff	17.12	4.28	6.77	18 50
National Milling Co.'s Wheat Feed	17.02	4.62	8.34	19 00
Wheat Bran	16.63	4.78	8.62	21 13
Harter's Mixed Feed	16.44	4.39	7.60	19 00
Germ Oil Meal	16.29	9.65	......	22 75

II. Carbohydrate Feeds.

Glucose Sugar Refining Co.'s Corn Bran or Sugar Feed	13.36	3.44	12.00	$17 10
Quaker Dairy Feed	13.19	3.22	17.64	18 86
H. O. Horse Feed	12.61	3.89	9.63	21 88
C. H. Kirby's Dairy Feed	12.48	3.24	5.29	18 50
J. C. Smith & Wallace's Dairy Feed	12.31	5.00	6.06	19 00
Schuhmacher Stock Feed	11.38	4.61	11.47	20 00
Hominy Meal or Feed	10.83	8.59	......	19 05
Taylor Bro.'s Dairy Feed, No. 2	10.80	3.54	9.67	17 50
J. A. Lydecker's Dairy Feed	10.51	7.42	7.33	20 00
Mixed Horse Feeds	10.38	4.66	5.22	20 68
Sugar Feeds (other than above)	9.69	5.18	12.49	17 64
Cerealine Feeds	9.55	6.88	......	19 75
Corn Meal	9.07	4.30	......	22 00
Victor Corn and Oat Feed	8.73	4.09	10.80	18 55
De Fi Corn and Oat Feed	8.70	3.13	14.89	19 00
Friend's Concentrated Dairy Feed	7.98	3.39	22.18	16 13

	Protein.	Fat.	Fiber.	Selling Price.
Taylor Bros.' Oat Feed	7.79	3.24	21.53	$15 00
Warren Beatty's Dairy Feed	7.47	3.84	6.88	17 00
Durham Corn and Oat Feed	7.47	2.80	13.06	20 00
Chester Stock Food	7.43	3.36	11.11	18 75
Royal Oat Feed	7.32	3.50	22.74	16 00
Vim Oat Feed	5.64	2.19	28.05	16 10
Sitley & Son's Oat Feed	3.32	1.20	31.42	14 50
Oat Chop	2.68	1.08	31.96	15 66
Sharpless & Bros.' Oat Feed	2.46	1.03.	32.41	....

III. Feeds Made from Whole Grains.

	Protein.	Fat.	Fiber.	Selling Price.
Horse Feeds	9.76	3.63	5.09	$21 56
Corn and Oats (Provender)	9.69	4.47	3.99	20 90
Corn Ear Meal ("Cob Meal")	7.73	3.52	5.90	15 41

IV. Poultry, Stock and Condimental Foods.

	Protein.	Fat.	Fiber.	Selling Price.
H. O. Poultry Feed	17.39	5.53	4.67	$30 86
H. O. Scratching Feed	12.32	4.43	......	32 00
American Poultry Food	12.99	6.57	4.74	28 00
Anderson's Old Fowl Mixture	17.86	5.72	4.26	26 00
Hopkins & Lippincott's Poultry Feed	18.23	9.11	7.46	30 00
Paul T. Norton Poultry Feed	15.46	4.44	4.60	23 00
Fidelity Food for Young Chicks	19.85	6.67	......	....
Blatchford's Calf Meal	24.90	5.29	4.66	68 33
American Calf Meal	17.44	8.01	2.32	41 00
Banner Stock Food	22.84	8.40	......	160 00
Baum's Horse and Stock Food	24.84	*9.20	18.32	200 00
Bowker's Animal Meal	42.05	8.31	......	46 66
Bowker's Ground Beef Scrap	53.59	14.92	......	50 00
Shoemaker's Ground Meat for Poultry	60.91	13.01	......	52 00

* Ether extract, including much sulphur.

I. PROTEIN FEEDS.

1. Cottonseed Meal.

Station Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	American Cotton Oil Co., N. Y. City.		%	%	%	%	
1172	J. H. Blauvelt & Sons	Ridgewood	41.56	43	9.10	9	$30 00
1194	J. C. Smith & Wallace Co.	Newark	46.35	43	8.87	9	27 00
1195	Wilkinson, Gaddis & Co.	Newark	46.03	43	8.69	9	28 00
1237	Jaqui & Co.	Morristown	47.81	43	10.10	9	30 00
1238	Jos. Benedict	Elizabeth	46.69	43	10.04	9	29 00
1269	Van Zandt & Voorhees	Plainfield	46.60	43	9.65	9	33 00
1317	Allen & Stults	Trenton	45.0[illegible]	43	8.80	9	28 00
1401	J. K. Waddington	Salem	44.88	43	9.64	9	29 00
1542	J. L. Hope	Madison	51.49	43	9.16	9	25 60
1265	C. Pountney	Elizabeth	46.03	43	9.74	9	27 00
1498	T. A. Ward	Freehold	45.90	43	9.20	9	30 00
	Cotton Oil and Fiber Co., Norfolk, Va.						
1198	Drake & Co	Newark	48.21	43	8.63	9	29 00
1220	Carscallen & Cassidy	Jersey City	48.21	43	8.80	9	30 00
1341	Sharpless & Bro.	Camden	47.86	43	8.64	9	26 00
1379	S. L. Pancoast	Mullica Hill	48.55	43	8.72	9	30 00
1407	C. G. Lippincott	Salem	47.29	43	9.02	9	28 00
1425	M. E. Lush	Vineland	47.40	43	9.34	9	30 00
1426	J. J. Hunt	Vineland	47.69	43	9.31	9	30 00
1367	Taylor Bros.	Camden	47.12	43	9.17	9	26 00
1421	Fithian & Pennell	Bridgeton	46.03	43	10.11	9	30 00
1422	Mixner & Mickle	Bridgeton	41.66	43	11.62	9	30 00
1423	W. O. Garrison	Bridgeton	47.48	43	10.21	9	30 00
1430	Vineland Grain Co	Vineland	46.83	43	9.04	9	28 00
1438	E. L. Ross	Cape May C. H.	45.56	43	9.99	9	32 00
1490	Colkitt & Thomson	Mt. Holly	47.59	43	9.21	9	29 00
1502	J. P. Wyckoff	Manasquan	41.51	43	10.54	9	32 00
	Cole, Cleaveland & Curley, N. Y. City.						
1181	C. A. Wilson	Deckertown	45.51	43	10.20	9	27 00
1146	*Simmons & Martin*	*Deckertown*	46.14	43	10.39	9	27 00
	Chapin & Co., St. Louis, Mo.						
1052	W. H. Ingersoll	Hamburg	48.76	43	7.72	9	27 00
	J. E. Soper & Co., Boston, Mass.						
1209	A. Cyphers	Newark	48.09	43	9.11	9	28 00
	F. S. Walton & Co., Philadelphia, Pa.						
1121	Samuel Thomas	Phillipsburg	45.73	43	9.95	9	29 00
	F. W. Brode & Co., Memphis, Tenn.						
1330	Sitley & Son	Camden	42.71	43	8.20	9	....
1467	*Hopkins & Lippincott*	*Moorestown*	38.03	43	12.38	9	27 00
1468	J. S. Collins & Son	Moorestown	39.60	43	9.46	9	26 00
	Simpson, Hendee & Co., N. Y. City.						
1325	L. B. Risdon	Trenton	44.20	43	8.00	9	26 00
	Hunter Bros., St. Louis, Mo.						
1356	C. H. Kirby	Medford	46.14	43	10.18	9	27 50
	Sledge & Wells Co., Memphis, Tenn.						
1544	J. E. Stevenson	Columbus	41.19	......	9.79	......	....
		Average	45.71	......	9.48	......	28 70

I. PROTEIN FEEDS.

2. Linseed Meal, Oil Meal, or Cake Meal.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	American Linseed Co., Chicago, Ill.		%	%	%	%	
1143	C. A. Wilson	Deckertown	32.76	32	6.75	5	$33 00
1179	J. H Blauvelt & Sons	Ridgewood	32.13	32	7.79	5	32 00
1197	Wilkinson, Gaddis & Co	Newark	31.83	32	7.23	5	31 00
1215	Vile & Sons	Jersey City	33.78	32	7.80	5	35 00
1219	A. Hannibal	Hoboken	32.41	32	6.75	5	30 00
1286	Nischwitz & Kitchen	Plainfield	31.60	32	7.00	5	40 00
1377	S. L. Pancoast	Mullica Hill	29.54	32	8.89	5	35 00
1120	J. L. Hance	Hackettstown	35.54	32	6.73	5	30 00
1326	L. B. Risdon	Trenton	29.89	32	7.36	5	30 00
1263	Jos. Benedict	Elizabeth	32.86	32	6.58	5	32 00
1196	J. C. Smith & Wallace Co	Newark	32.74	32	6.91	5	30 00
1216	Carscallen & Cassidy	Jersey City	35.15	32	8.08	5	36 00
1217	Long Dock Mills and Elevator	Jersey City	30.84	32	8.89	5	27 00
1218	Hanks & Co	Jersey City	31.26	32	8.53	5	....
1254	Jaqui & Co	Morristown	32.98	32	6.54	5	34 00
1303	Mundy Bros	Bound Brook	31.94	32	7.17	5	34 00
1288	R. F. Hohenstein	Westfield	31.83	32	7.25	5	40 00
1306	P. J. Staats	Bound Brook	32.52	32	7.34	5	31 00
1447	C. W. Russell	New Brunswick	33.13	32	7.66	5	35 00
1389	Samuel Auderson	Hammonton	36.76	32	9.75	5	35 00
1541	J. L. Hope	Madison	32.76	32	7.75	5	29 00
1349	J. S. Middleton	Camden	31.43	32	6.49	5	30 00
1147	Simmons & Martin	Deckertown	31.80	32	6.81	5	35 00
1178	P. O'Blenis	Paterson	31.59	32	7.09	5	32 00
1284	Meyer & De Vogel	Paterson	32.98	32	7.25	5	32 00
1396	Theo. Messinger	Egg Harbor City	32.86	32	7.61	5	35 00
1397	D. W. McClain	May's Landing	32.41	32	6.66	5	40 00
1398	J. C. Johnson	Hammonton	33.66	32	7.80	5	35 00
1399	E. Stockwell	Hammonton	31.66	32	6.61	5	35 00
1417	J. B. Rose & Son	Millville	31.38	32	6.90	5	36 00
1418	Mixner & Mickle	Bridgeton	34.24	32	7.41	5	35 00
1419	E. L. Langley & Co	Millville	32.39	32	6.92	5	*60 00
1420	Fithian & Pennell	Bridgeton	34.69	32	6.83	5	*55 00
1431	Vineland Grain Co	Vineland	31.60	32	6.69	5	32 00
1416	*W. O. Garrison*	*Bridgeton*	*31.05*	*32*	*6.46*	*5*	*35 00*
1408	J. K. Waddington	Salem	31.94	32	9.52	5	33 00
1500	Robt. Pearce & Sons	Red Bank	32.29	32	7.30	5	40 00
1467	J. S. Collins & Son	Moorestown	31.89	32	6.57	5	32 00
1518	L. E. Brown	Red Bank	32.85	32	8.21	5	30 00
1519	R. Hance	Red Bank	32.29	32	7.28	5	38 00

*Omitted from the average.

I. PROTEIN FEEDS.

2. Linseed Meal, Oil Meal or Cake Meal.—Con.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	American Linseed Co., Chicago, Ill.—Con.		%	%	%	%	
1520	Petty & Applegate	Perth Amboy	32.18	32	6.93	5	$40 00
1223	Miller & Bertholf	Jersey City	35.04	32	7.45	5	30 00
1388	Geo. Elvins	Hammonton	36.76	32	9.55	5	34 00
	T. J. Preston, Newark, N. J.						
1284	C. Frank French	Plainfield	34.93	32	7.88	5	38 00
1205	A. Cyphers	Newark	35.49	32	7.35	5	32 00
1206	Drake & Co	Newark	36.53	32	6.58	5	32 00
1256	The Paul T. Norton Co	Elizabeth	35.73	32	6.53	5	32 00
1285	A. L. Cadmus	Plainfield	32.41	32	12.41	5	36 00
1276	Van Zandt & Voorhees	Plainfield	35.15	32	7.69	5	35 00
1283	The Paul T. Norton Co	Plainfield	35.73	32	6.23	5	32 00
1499	C. H. Snyder & Son	Freehold	35.16	32	7.24	5	36 00
1515	The Paul T. Norton Co	Red Bank	34.48	32	7.87	5	38 00
	Sharpless & Bro., Camden, N. J.						
1338	Sharpless & Bro	Camden	37.38	....	6.90	......	31 00
1392	G. Ripley	May's Landing	37.67	....	6.78	......	40 00
1428	J. J. Hunt	Vineland	36.29	....	11.49	......	34 00
1429	M. E. Lush	Vineland	36.53	....	7.09	......	36 00
1496	Colkitt & Thomson	Mount Holly	37.24	....	6.56	......	40 00
	Sitley & Son, Camden, N. J.						
1345	Sitley & Son	Camden	35.73	32	9.49	5	28 75
1394	Chas. Cast	Egg Harbor City	37.79	32	6.92	5	35 00
1435	D. W. Rodan	Cape May City	27.56	32	8.59	5	*50 00
	Titus, Wells & Willis, N. Y. City.						
1232	Wm. Veldran & Sons	Oradell	28.74	....	6.71	......	37 00
	Hauenstein & Co., Buffalo, N. Y.						
1297	R. B. Beatty	North Branch	37.33	40.96	8.07	8.65	34 00
	W. S. Woodward, Philadelphia, Pa.						
1383	H. A. Fish	Woodbury	35.49	....	6.00	......	40 00
	Manufacturer Unknown.						
1262	C. Pountney	Elizabeth	23.70	....	5.53	......	....
1280	Wm. Lunger	Plainfield	35.49	....	7.01	......	38 00
1324	J. E. Stevenson Co.	Trenton	33.78	....	7.27	......	30 00
1443	T. C. Dugan	New Brunswick	32.06	....	7.29	.....	35 00
1509	Thos. Eggert & Co	Perth Amboy	33.19	....	9.04	......	35 00
		Average	33.50	....	7.49	.....	34 08

* Omitted from the average.

I. PROTEIN FEEDS.

3. Flaxseed Meal.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
			%	%	%	%	
1816	Allen & Stults	Trenton	25.25	....	37.43	.....	....
1828	J. E. Stevenson Co.	Trenton	23.82	....	37.00	.....	....
1848	Sharpless & Bro.	Camden	24.39	....	37.52	.....	$80 00
1350	Taylor Bros.	Camden	*18.15	....	*25.48	.....	100 00
1395	Wm Heald Co.	Atlantic City	24.84	....	37.64	.....	140 00
1846	Sitley & Son	Camden	*17.75	....	*25.12	.....	75 00
1436	D. W. Rodan	Cape May City	*19.35	....	*26.03	.....	100 00
		Average	24.58	....	37.40	.....	....

4. Chicago Gluten Meal.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co., Chicago, Ill.						
1018	R. J. Kimble	Monroe	35.43	39.50	6.13	3.37	25 50
1040	R. V. Northrup	Augusta	38.95	39.00	2.50	3.37	26 50
1041	A. N. Roe	Branchville	37.03	36.00	3.75	3.37	26 50
1332	Sitley & Son	Camden	38.81	38.00	4.07	3.30	25 00
1855	Taylor Bros	Camden	37.67	38.00	3.15	3.30	26 00
1485	W. D. Rogers & Co.	Moorestown	37.69	39.50	3.83	3.37	27 00
		Average	37.60	....	3.91	.....	26 08

5. Davenport Gluten Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co.						
1107	J. A. Wintermute	Middleville	24.44	27.33	3.78	2.96	20 60
1152	A. D. Cornell	Stillwater	24.71	27.33	4.18	2.96	22 00
1548	Chas. Wright	Columbus	24.01	28.00	3.29	.....	19 50
		Average	24.39	....	3.75	.....	20 70

6. Waukegan Gluten Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	U. S. Sugar Refining Co., Waukegan, Ill.						
1048	A. N. Roe	Branchville	26.36	27.88	4.34	3.39	21 50

*Omitted from average.

I. PROTEIN FEEDS.

7. Buffalo Gluten Feed.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co., *Chicago, Ill.*		%	%	%	%	
1058	C. T. Mott & Co.	Vernon	26.04	27.00	3.49	3.00	$21 00
1059	Stephen Roy	Glenwood	27.48	27.00	3.18	3.00	21 00
1018	R. J. Kimble	Monroe	26.89	28.00	2.86	3.00	21 00
1169	R. Corsen	Blair	27.43	......	2.89	......	21 00
1333	Sitley & Son	Camden	26.68	28.00	4.25	3.30	20 00
1380	C. H. Kirby	Medford	26.84	......	3.26	......	21 00
1381	S. L. Paneoast	Mullica Hill	26.84	28.00	3.17	2.00	21 00
1382	C. C. Turner	Penn's Grove	23.36	28.00	3.08	3.30	22 00
1391	Chas. Cast	Egg Harbor City	26.56	27.50	3.54	3.00	25 00
1410	W. O. Garrison	Bridgeton	26.85	27.50	4.00	3.30	23 00
1412	Mixner & Mickle	Bridgeton	26.62	......	4.10	......	23 00
1483	W. D. Rogers & Co	Moorestown	25.3	27.50	4.10	3.00	22 00
1354	Taylor Bros	Camden	26.89	27.50	3.46	3.30	20 50
1390	G. Elvins	Hammonton	26.82	28.00	3.60	3.30	24 40
1405	J. K. Waddington	Salem	26.49	......	4.46	......	21 00
1413	Fithian & Pennell	Bridgeton	28.13	27.50	4.10	3.00	23 00
		Average	26.51	......	3.60	......	21 87

8. Rockford Diamond Gluten Feed.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co.						
1062	W. H. Ingersoll	Hamburg	26.89	27.00	3.95	3.00	20 50
1153	R. Harden	Hamburg	27.64	27.00	3.53	3.00	20 80
1221	Long Dock Mills and Elevator	Jersey City	27.31	26.20	2.68	2.70	......
1246	Jaqui & Co	Morristown	27.43	27.00	3.25	3.00	22 00
		Average	27.32	......	3.34	......	21 10

9. Marshalltown Gluten Feed.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co.						
1247	Jaqui & Co	Morristown	29.20	27.00	3.44	3.00	22 00

10. Other Gluten Feeds.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Selling Price per Ton.
	Glucose Sugar Refining Co.						
1255	The Paul T. Norton Co	Rahway	22.79	......	2.88	......	......
	National Starch Mfg. Co., N. Y. City.						
1322	L. B. Risdon	Trenton	28.74	28.40	4.42	4.80	22 00
1319	L. B. Risdon	Trenton	29.89	......	3.63	......	22 00
1285	Meyer & De Vogel	Paterson	26.11	......	4.23	......	22 00
1314	Allen & Stults	Trenton	24.50	......	5.68	......	22 00
1327	J. E. Stevenson Co.	Trenton	22.10	......	3.00	......	22 00
1033	R. V. Northrup	Augusta	20.12	21.20	2.58	2.90	21 00
1517	Thos. Eggert & Co	Perth Amboy	29.70	......	4.23	......	22 00
		Average	25.38	......	3.96	......	21 86
	Manufacturer Unknown.						
1840	Sharpless & Bro	Camden	25.65	......	5.89	......	21 00

I. PROTEIN FEEDS.

11. Dried Brewers' Grains.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Selling Price per Ton.
	E. P. Mueller, Chicago, Ill.		%	%	%	%	
1078	A. Emmons	Halsey	26.58	23.85	7 22	6.13	$18 00
1162	C. A. Wilson & Co	Deckertown	26.51	23.85	7.91	6.13	19 00
1261	Kynor & Looker	Boonton	26.79	23.85	7.8-	6.13	19 60
1444	T. C. Dugan	New Brunswick	25.71	23.85	7.89	6.13	19 00
	Gottfried Krueger Brewing Co., Newark, N. J.						
1523	Sent by College Farm	New Brunswick	25.59	23.71	9.24	7.80	17 60
	P. C. Kamm & Co., Milwaukee, Wis.						
1068	Hopkins & Williams	Deckertown	26.58	......	7.60	......	19 00
1185	J. A. Lydecker	Paterson	27.82	......	7.39	......	20 00
	Alfred Meurer Co., Milwaukee, Wis.						
1094	D. B. Keyser	Vail	29.24	26.81	7.12	7.20	19 00
	J. C. Klauder, Philadelphia, Pa.						
1342	Sharpless & Bro	Camden	23.41	31.63	9.16	6.84	18 50
1374	Taylor Bros	Camden	22.59	31.63	7.95	6.84	19 00
1438	Vineland Grain Co	Vineland	26.56	31.00	7.21	6.00	21 00
1481	Hopkins & Lippincott	Moorestown	22.16	31.63	7.00	6.34	18 00
1497	Colkitt & Thomson	Mount Holly	21.49	31.63	6.90	6.34	20 00
	Manufacturer Unknown.						
1445	C. W. Russell	New Brunswick	26.33	......	7.64	......	18 75
1478	J. S. Collins & Son	Moorestown	26.66	......	8.00	......	19 50
		Average	25.57	......	7.74	......	19 06

12. Malt Sprouts.

	E. P. Mueller, Chicago, Ill.						
1074	C. T. Mott & Co	Vernon	25.19	26.25	2.27	1.01	17 00
1259	Kynor & Looker	Boonton	27.91	26.25	2.87	1.01	18 00
1054	Stephen Roy	Glenwood	24.54	26.25	3.09	1.01	17 00
1321	J. H. Ashton	Trenton	27.14	26.25	2.72	1.01	17 00
1070	E. A. Carpenter	Baleville	27.32	26.25	2.13	1.01	16 75
1186	J. A. Lydecker	Paterson	28.90	26.25	2.12	1.01	19 00
	Gottfried Krueger Brewing Co., Newark, N. J.						
1514	Sent by manufacturer	Factory	24 93	......	3.50	......	......
	M. G. Rankin & Co., Chicago, Ill.						
1022	Hopkins & Williams Co	Newton	25.19	26.25	3.06	1.01	17 50
1076	A. Emmons	Halsey	24.12	......	2.32	......	18 00
1095	D. B. Keyser	Vail	25.88	24.80	1.93	1.70	17 00
	John Rankin & Co., Chicago, Ill.						
1164	C. A. Wilson & Co	Deckertown	24.39	24.00	1.57	......	18 00
	Hottelet & Co., Milwaukee, Wis.						
1089	A. B. Albert	Danville	23.91	28.96	2.20	1.66	17 50
1159	Simmons & Martin	Deckertown	24.28	28.96	2.90	1.66	17 50
	American Malting Co., Buffalo, N. Y.						
1031	A. N. Roe	Branchville	26.79	......	1.44	......	17 50
	M. F. Barringer, Philadelphia, Pa.						
1133	R. Corsen	Blair	28.05	......	3.70	......	17 00

I. PROTEIN FEEDS.

12. Malt Sprouts.—Con.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
			%	%	%	%	%	
	Arthur J. Clapp, N. Y. City.							
1017	B. K. Hopkins	Lafayette	22.79	....	2.28	....	....	$17 00
	F. K. Fish, New York City.							
1182	Meyer & DeVogel	Paterson	24.65	10.00	3.30	0.50	....	18 00
	F. W. Goeke & Co., St. Louis, Mo.							
1011	J. B. Wintermute	Newton	26.58	24.80	3.19	1.70	....	17 75
	Henry Rang & Co., Chicago, Ill.							
1323	J. E. Stevenson Co	Trenton	25.88	....	2.62	....	....	18 00
	Manufacturer Unknown.							
1163	W. R. Morris	Fredon	24.28	....	3.33	....	....	17 50
1176	*P. O'Blenis	Paterson	27.48	....	2.34	....	....	18 00
1347	Sitley & Son	Camden	30.23	25 19	2.24	0.67	....	17 00
1370	Taylor Bros	Camden	23.01	25.19	2.96	0.67	....	17 00
		Average	25.59	....	2.59	....	....	17 50

13. Wheat Feeds.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	American Cereal Co.'s Buckeye Feed.							
1003	S. S. Wills	Andover	17.50	16.21	4.22	4.48	5.06	20 00
1027	S. Hill	Newton	16.70	16.21	4.49	4.48	5.64	20 00
1170	T. Brown	New Foundland	17.18	16.21	4.75	4.48	7.13	21 00
		Average	17.13	....	4.49	....	5.94	20 33
	Harter's Mixed Feed.							
1158	R. Harden	Hamburg	16.44	....	4.39	....	7.60	19 00
	National Milling Co.'s Mixed Feed.							
1136	R. Harden	Hamburg	17.02	....	4.62	....	8.34	19 00
	Rankin's Wheat Feed.							
1047	A. N. Roe	Branchville	17.29	....	4.37	....	5.86	19 00
	Hoosier Mill Feed.							
1451	Henry Banker	New Brunswick	18.39	....	4.70	....	7.07	20 00
	Wheat Bran.							
1378	Barber & Turner (Winter)	Penn's Grove	17.86	....	4.20	....	6.70	20 00
1066	W. H. Ingersoll	Hamburg	15.74	....	4.67	....	9.01	18 50
1363	C. H. Kirby (Spring)	Medford	16.43	....	5.08	....	10.41	21 00
1365	Taylor Bros. (Spring)	Camden	16.26	....	5.16	....	9.74	20 50
1366	Taylor Bros. (Winter)	Camden	17.18	....	4.66	....	7.20	21 00
1387	Chas. Cast	Egg Harbor City	16.38	....	5.10	....	8.59	24 00

* Later reported as product of Lake Ontario Malting Co., Oswego, N. Y.

I. PROTEIN FEEDS.

13. Wheat Feeds.—Con.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Wheat Bran.—Con.		%	%	%	%	%	
1448	Runyon Bros.	New Brunswick	16.99	....	4.74	....	6.71	$20 00
1446	C. W. Russell	New Brunswick	16.65	....	5.11	....	10.97	19 00
1453	L. L. Holcombe	Flemington	16.76	....	5.23	....	9.16	19 00
1459	H. A. Ford (Spring)	Allentown	15.86	....	4.99	....	10.28	21 00
1460	*H. A. Ford (Winter)*	*Allentown*	*13.73*	....	*4.43*	....	*7.92*	*21 00*
1480	W. D. Rogers & Co. (Winter)	Moorestown	17.66	....	4.64	....	7.99	21 00
1491	Colkitt & Thomson (Spring)	Mount Holly	16.31	....	5.17	....	9.72	21 00
1505	T. A. Ward	Freehold	17.78	....	4.53	....	8.05	24 00
1508	J. P. Wyckoff (Winter)	Manasquan	18.68	....	4.36	....	6.46	24 00
1513	Petty & Applegate (Winter)	Perth Amboy	15.75	....	4.49	....	9.00	23 00
		Average	16.63	....	4.78	....	8.62	21 13
	Ship Stuff.							
1055	C. G. Clark & Co.	Westown	16.83	....	4.25	....	6.84	18 00
1161	C. A. Wilson & Co.	Deckertown	17.41	....	4.31	....	6.70	19 00
		Average	17.12	....	4.28	....	6.77	18 50
	14. H. O. Dairy Feed.							
	The H. O. Co., Buffalo, N. Y.							
1204	A. Cyphers	Newark	19.69	18.00	3.95	4.50	13.12	25 00
1253	Jos. Benedict	Elizabeth	19.29	18.00	3.76	4.50	12.01	23 00
1300	Mundy Bros.	Bound Brook	17.81	18.00	3.80	4.50	12.36	22 00
1320	L. B. Risdon	Trenton	17.12	18.00	3.98	4.50	12.95	22 00
1357	C. H. Kirby	Medford	18.21	18.00	3.78	4.50	13.32	21 50
		Average	18.42	....	3.85	....	12.75	22 70
	15. Miscellaneous.							
	Sucrene Dairy Feed, American Milling Co.							
1402	J. K. Waddington	Salem	21.75	16.50	6.90	3.50	8.96	21 00
	Germ Oil Meal, Cerealine Mfg. Co.							
1141	C. A. Wilson & Co.	Deckertown	16.11	....	8.40	....	....	25 00
1472	W. D. Rogers & Co.	Moorestown	17.66	....	9.20	....	....	22 00
1474	J. S. Collins & Son	Moorestown	14.79	....	12.79	....	....	22 00
1476	Hopkins & Lippincott	Moorestown	16.59	....	8.22	....	....	22 00
		Average	16.29	....	9.65	....	....	22 75

II. CARBOHYDRATE FEEDS.

1. Hominy Meal or Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%	
1029	S. Hill	Newton	10.83	10.74	7.89	6.20	....	$20 00
	American Malting Co., Detroit, Mich.							
1056	*E. A. Carpenter*	*Baleville*	*10.78*	*9.89*	*8.47*	*7.06*	....	*18 50*
	M. F. Barringer, Philadelphia, Pa.							
1134	W. R. Morris (White)	Fredon	11.10	....	8.41	....	....	19 00
1135	W. R. Morris (Yellow)	Fredon	12.11	....	8.88	....	....	19 00
1034	R. V. Northrup	Augusta	11.21	....	9.14	....	....	19 00
	Columbia Flour and Grain Co., Newark, N. J.							
1035	A. N. Roe	Branchville	*7.90	....	*5.70	....	11.86	18 00
	Chapin & Co., St. Louis, Mo.							
1053	W. H. Ingersoll	Hamburg	10.35	11.00	8.83	8.00	....	18 00
	F. K. Fish, New York City.							
1181	P. O'Bienis	Paterson	10.53	7.00	7.59	5.00	....	19 00
	The Hudnut Co., Terre Haute, Ind.							
1060	Stephen Roy	Glenwood	10.89	12.85	8.68	8.52	....	18 00
	Indianapolis Hominy Mills, Indianapolis, Ind.							
1042	C. T. Mott & Co	Vernon	11.10	11.64	8.52	8.08	....	20 00
1023	G. O. Young	Andover	10.68	11.10	9.31	10.47	....	18 00
	J. S. Lapham & Co., Detroit, Mich.							
1100	D. C. Hallet	Stillwater	10.35	10.15	8.48	6.63	....	18 40
	G. Q. Moon & Co., Binghamton, N. Y.							
1044	J. C. Ellett	Branchville	10.78	....	8.60	....	....	19 00
	Shellabarger Milling and Elevator Co., Decatur, Ill.							
1160	Simmons & Martin	Deckertown	10.56	10.76	8.90	8.64	....	19 00
1189	J. English	Paterson	11.21	11.14	9.80	9.02	....	20 00
	Simpson, Hendee & Co., New York City.							
1192	J. English	Paterson	9.50	9.89	6.74	7.06	....	20 00
1250	Jaqui & Co	Morristown	12.08	....	10.17	....	....	20 00
	Suffern, Hunt & Co., Decatur, Ill.							
1166	R. Corsen	Blair	11.86	11.02	8.97	7.77	....	20 00
	M. M. Wright & Co., Danville, Ill.							
1167	A. D. Cornell	Stillwater	10.14	10.93	8.65	8.00	....	19 00
	Manufacturer Unknown.							
1229	Holly & Smith	Hackensack	10.18	....	7.17	....	....	....
		Average	10.83	....	8.59	....	....	19 05

* Not included in average.

II. CARBOHYDRATE FEEDS.

2. Quaker Dairy Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%	
1001	S. S. Wills	Andover	12.06	12.03	2.88	2.50	17.99	$18 00
1026	S. Hill	Newton	12.70	12.03	3.38	2.50	15.66	18 00
1099	W. Beatty	Hainesburg	13.05	12.03	3.05	2.50	16.95	18 00
1224	J. J. Bell	New Milford	13.41	12.03	3.50	2.50	18.63	....
1376	H. A. Fish	Woodbury	13.11	12.03	3.01	2.50	20.82	19 00
1268	Nischwitz & Kitchen	Plainfield	15.11	12.03	3.21	2.50	15.80	20 00
1309	J. E. Stevenson Co.	Trenton	12.59	12.03	3.15	2.50	17.38	20 00
1464	W. D. Rogers & Co.	Moorestown	13.50	12.03	3.56	2.50	17.90	19 00
		Average	13.19	....	3.22	....	17.64	18 86

3. Victor Corn and Oat Feed.

	American Cereal Co., Chicago, Ill.							
1010	*G. O. Young*	Andover	*9.44*	*8.23*	*4.02*	*3.00*	*9.75*	*18 00*
1004	Hopkins & Williams Co.	Newton	8.96	8.23	4.19	3.00	9.16	17 50
1213	A. Hannibal	Hoboken	7.61	8.23	3.24	3.00	13.28	20 00
1225	J. J. Bell	New Milford	8.59	8.23	4.86	3.00	12.06	....
1463	W. D. Rogers & Co.	Moorestown	9.45	8.23	4.56	3.00	6.67	19 00
1267	A. L. Cadmus	Plainfield	8.36	8.23	4.21	3.00	12.40	18 00
1289	Mundy Bros.	Bound Brook	8.48	8.23	4.21	3.00	11.61	19 00
1312	J. H. Ashton	Trenton	8.48	8.23	4.47	3.00	11.87	18 00
1127	Simmons & Martin	Deckertown	9.00	8.23	4.17	3.00	12.01	17 00
1212	Hanks & Co.	Jersey City	8.21	8.23	3.80	3.00	10.92	....
1214	Miller & Bertholf	Jersey City	8.21	8.23	3.69	3.00	10.61	19 00
1266	Nischwitz & Kitchen	Plainfield	10.01	8.23	3.67	3.00	9.37	20 00
		Average	8.73	....	4.09	....	10.80	18 55

4. Corn, Oat and Barley Feed (Schumacher Stock Feed).

	American Cereal Co., Chicago, Ill.							
1009	G. O. Young	Andover	11.42	10.79	4.69	3.29	11.14	20 00
1129	C. A. Wilson & Co.	Deckertown	11.34	10.79	4.53	3.29	11.80	20 00
		Average	11.38	....	4.61	....	11.47	20 00

II. CARBOHYDRATE FEEDS.

5. H. O. Horse Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	The H. O. Co., Buffalo, N. Y.		%	%	%	%	%	
1702	Drake & Co	Newark	12.71	12.00	4.13	4.50	9.60	$22 00
1222	Vile & Sons	Jersey City	12.03	12.00	3.82	4.50	9.33	22 00
1251	Jos. Benedict	Elizabeth	12.37	12.00	3.76	4.50	8.98	23 00
1358	C. H. Kirby	Medford	12.71	12.00	3.32	4.50	10.65	21 00
1299	Mundy Bros	Bound Brook	12.48	12.00	4.05	4.50	10.18	21 00
1336	J. S. Middleton	Camden	12.71	12.00	3.86	4.50	9.51	22 00
1479	W. D. Rogers & Co	Moorestown	12.60	12.00	3.86	4.50	9.44	22 00
1450	Runyon Bros	New Brunswick	13.28	12.00	4.85	4 50	9.33	22 00
		Average	12.61	....	3.89	....	9.63	21 88

6. Corn Bran or Sugar Feed.

	Glucose Sugar Refining Co., *Chicago, Ill.*							
1014	Hopkins & Williams Co	Newton	13.29	13.50	3.44	3.70	12.26	17 00
1024	G. O. Young	Andover	13.98	13.50	3.03	3.70	12.01	15 00
1086	D. B. Keyser	Vail	13.34	13.50	3.22	3.70	11.94	16 50
1364	C. H. Kirby	Medford	13.63	13.50	3.68	3.70	10.91	18 00
1404	J. K. Waddington	Salem	12.54	13.50	3.82	3.70	12.89	19 00
		Average	13.36	....	3.44	....	12.00	17 10
	John Rankin & Co., Chicago, Ill.							
1039	C. T. Mott & Co	Vernon	9.29	9.19	3.54	4.55	13.71	17 00
	Wm. T. Reynolds & Co., Poughkeepsie, N. Y.							
1165	C. A. Wilson & Co	Deckertown	8.75	9.44	4.80	1.60	13.71	16 00
	Chas. Pope Glucose Co., Chicago, Ill.							
1050	E. A. Carpenter	Baleville	10.68	11.75	4.29	5.00	14.74	16 50
	Taylor Bros., Camden, N. J.							
1375	Taylor Bros	Camden	9.22	....	4.65	....	7.92	19 00
1371	Taylor Bros	Camden	8.76	10.31	8.08	1.73	9.89	17 00
1415	W. O. Garrison	Bridgeton	11.22	10.31	3.22	1.73	13.30	22 00
1475	Hopkins & Lippincott	Moorestown	9.90	....	7.70	....	14.16	16 00
		Average	9.69	....	5.18	....	12.49	17 64

II. CARBOHYDRATE FEEDS.

7. Cerealine Feeds.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN.		FAT.		Crude Fiber.	Selling Price per Ton.
			Found.	Guaranteed.	Found.	Guaranteed.		
	Cerealine Mfg. Co., Indianapolis, Ind.		%	%	%	%	%	
1012	Hart & Ilift	Newton	11.58	13.19	8.74	6.07	....	$19 60
1032	McDanolds & Lance	Branchville	10.56	14.00	7.24	7.29	....	19 00
1137	Reeve Harden	Hamburg	9.91	13.19	7.22	6.07	....	20 00
1138	Simmons & Martin	Deckertown	10.59	14.00	7.08	7.29	....	20 00
1331	Sitley & Son	Camden	11.34	10.82	8.52	7.57	....	18 50
1469	W. D. Rogers & Co	Moorestown	7.59	7.88	5.26	5.45	....	21 00
1470	J. S. Collins & Son	Moorestown	7.31	7.88	5.22	5.45	....	20 00
1471	Hopkins & Lippincott	Moorestown	7.54	7.85	5.73	5.45	....	20 50
		Average	9.65	....	6.88	....	....	19 75

8. Horse Feeds (Not Made from Whole Grains).

		Ingredients.						
1082	Belvidere Flour Mill Co., Belvidere, N. J.	Rye bran and middlings, corn, oats, corn ears and Vim Oat Feed,	10.68	....	3.69	....	5.25	18 00
1175	P. O'Blenis, Paterson, N. J.	Hominy, oat feed, corn and middlings	11.56	....	5.82	....	9.79	20 00
1015	A. D. Cornell, Stillwater, N. J.	Oats, hominy and wheat bran	11.11	....	6.23	....	5.80	23 00
1036	C. H. Crisman, Branchville, N. J.	Corn, rye, oats, wheat bran and buckwheat middlings	11.21	....	3.98	....	3.29	22 00
1088	Luther Emery, Portland, Pa. (Albertson & Davison, Columbia, N. J.)	Corn, rye and wheat bran	8.96	....	2.70	....	1.96	22 00
1180	Joseph English, Paterson, N. J.	Hominy, oat chop and rye middlings	10.68	....	7.24	....	8.79	20 00
1157	Reeve Harden, Hamburg, N. J.	*Cerealine feed* No. 2, oats, wheat bran and rye middlings	12.25	....	6.05	....	4.83	22 00
1064	W. H. Ingersoll, Hamburg, N. J. (Hercules)	Hominy, oats, wheat or rye middlings and buckwheat middlings	13.77	10.00	6.33	5.00	4.92	22 00
1067	W. H. Ingersoll, Hamburg, N. J. (Utility)	....	10.56	10.00	5.33	4.50	6.00	20 00

II. CARBOHYDRATE FEEDS.

8. Horse Feeds (Not Made from Whole Grains)—Con.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
		Ingredients.	%	%	%	%	%	
1249	Jaqui & Co., Morristown, N. J.	Hominy and Chester Stock Food	9.85	....	5.56	....	8.84	$21 00
1092	I. B. Keener, Belvidere, N. J..	Corn, oats, rye bran and middlings.....	10.62	....	3.81	....	2.85	18 00
1072	G. K. & O. H. McMurtrie, Belvidere, N. J......	Corn, oats, rye middlings and wheat screenings. ...	9.71	10.00	3.45	3.00	5.89	23 00
1111	G. K. & O. H. McMurtrie, Belvidere, N. J......	Corn, oats, rye middlings and wheat screenings....	10.31	10.00	3.15	3.00	4.19	22 00
1117	Pursel Mill and Coal Co., Phillipsburg, N. J...	Hominy, oat chop, corn and wheat bran.............	9.29	....	5.23	....	4.29	19 00
1304	P. J. Staats, Bound Brook, N. J.	Corn and oat feed,	8.93	....	3.81	....	4.85	21 00
1123	J. A. Wintermute, Middleville, N. J......	Corn, rye and hominy	9.90	....	5.24	....	8.87	20 00
1329	J. E. Stevenson Co., Trenton, N. J.........	Corn, oats and bran	10.08	....	4.15	....	2.94	22 00
1315	Allen & Stults, Trenton, N. J..	Corn, oats and bran	10.59	....	4.19	....	4.96	20 00
1521	F. C. Williams, Easton, Pa.	No. 1....................	10.91	....	3.80	....	2.48	23 00
1522	F. C. Williams, Easton, Pa.......	No. 2....................	10.01	....	4.98	....	4.01	20 00
1103	N. Dufford, Hackettstown, N. J. (City Feed).......	Corn ears and oat tailings...	8.01	....	3.61	....	6.72	16 00
1226	J. J. Bell, New Milford, N. J..	Victor, Quaker, corn, etc.......	9.28	....	4.11	....	9.98	21 00
		Average...........	10.38	....	4.66	....	5.22	20 68

9. Chester Stock Food.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Husted Mill and Elevator Co., Buffalo, N. Y. (A. J. Clapp, N. Y City, Agent.)							
1145	Simmons & Martin..................	Deckertown.......	7.26	11.50	3.12	4.20	12.15	18 00
1083	A. B. Albert..............................	Danville............	7.58	11.50	3.26	4.20	10.92	20 00
1227	Wm. Veldran & Sons................	Oradell	7.44	11.50	3.38	4.20	12.89	19 00
1271	A. Gray & Co............................	Dunellen	7.44	11.50	3.28	4.20	11.66	19 00
1020	J. B. Titman..............................	Sparta................	7.90	10.40	3.25	3.27	10.77	19 00
1144	C. A. Wilson & Co......................	Deckertown........	7.79	11.50	3.21	4.20	9.70	18 50
1245	Jaqui & Co.................................	Morristown.........	7.79	11.50	3.99	4.20	9.90	20 00
1272	A. L. Cadmus............................	Plainfield............	7.10	11.50	3.15	4.20	10.45	18 00
1084	G. K. and O. H. McMurtrie......	Belvidere............	7.10	11.50	3.40	4.20	10.89	19 00
1061	E. A. Carpenter.........................	Baleville.............	6.87	9.19	3.56	3.45	12.27	17 00
		Average	7.43	....	3.36	....	11.11	18 75

II. CARBOHYDRATE FEEDS.

10. Friend's Concentrated Dairy Feed.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Muscatine Oat Meal Co., Muscatine, Iowa.		%	%	%	%	%	
1021	E. J. Hardin	Allamuchy	7.15	10.70	3.13	3.70	22.47	$16 00
1016	Hopkins & Williams Co.	Newton	7.68	10.70	3.19	3.70	22.12	16 50
1837	Sharpless & Bro.	Camden	8.64	10.70	3.88	3.70	20.28	15 00
1495	Colkitt & Thomson	Mount Holly	8.44	10.70	3.35	3.70	23.85	17 00
		Average	7.98	......	3.39	......	22.18	16 13

11. Other Dairy Feeds.

1360	C. H. Kirby	Medford	12.48	......	3.24	......	5.29	18 50
1372	Taylor Bros. (No. 2)	Camden	11.11	12.62	3.53	3.06	8.62	16 00
1432	Taylor Bros. (No. 2)	Camden	10.48	12.00	3.54	2.75	10.73	19 00
1079	*Warren Beatty*	*Hainesburg*	*7.47*	......	*3.84*	......	*6.88*	*17 00*
1187	J. A. Lydecker	Paterson	10.51	......	7.42	......	7.33	20 00
1208	J. C. Smith & Wallace Co.	Newark	12.31	12.00	5.00	5.00	6.06	19 00

12. Oat Feeds.

	Amer. Cereal Co.'s Vim Feed.							
1005	Hopkins & Williams Co.	Newton	6.56	6.30	2.39	2.58	25.10	14 50
1171	Joseph English	Paterson	6.87	6.30	2.57	2.58	26.63	15 00
1240	Jaqui & Co.	Morristown	5.84	6.30	2.23	2.58	28.40	16 00
1352	C. H. Kirby	Medford	4.53	6.30	2.06	2.58	28.96	17 00
1290	P. J. Staats	Bound Brook	4.01	6.30	1.49	2.58	31.23	18 00
1233	Meyer & DeVogel	Paterson	6.02	6.30	2.37	2.58	28.00	......
		Average	5.64	......	2.19	......	28.05	16 10
	Akron Cereal Co.'s Royal Feed.							
1124	A. D. Cornell	Stillwater	7.86	8.25	3.76	4.14	22.71	16 00
1313	J. H. Ashton	Trenton	7.27	8.25	3.24	4.14	22.78	16 00
	A. E. Howe's Oat Chop.							
1183	Joseph English	Paterson	2.61	3.58	1.22	1.27	32.07	15 00
	F. K. Fish's Oat Chop.							
1063	W. H. Ingersoll	Hamburg	2.46	1.00	0.91	1.00	32.22	15 00
1248	*Joseph Benedict*	*Elizabeth*	*2.98*	*1.00*	*1.11*	*1.00*	*31.58*	*17 00*
	Manufacturer Unknown.							
1373	Taylor Bros.	Camden	7.79	8.75	3.24	2.56	21.53	15 00
1344	Sitley & Son	Camden	3.82	8.75	1.20	2.56	31.42	14 50
1339	Sharpless & Bro.	Camden	2.46	......	1.08	......	32.41	......

II. CARBOHYDRATE FEEDS.

13. De Fi Corn and Oat Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Elsworth & Co., Buffalo, N. Y.		%	%	%	%	%	
1403	J. K. Waddington	Salem	8.70	8.80	3.13	3.00	14.89	$19 00

14. Durham Corn and Oat Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	David Oliver, Joliet, Ill.							
1188	J. H. Blauvelt & Sons	Ridgewood	7.47	9.46	2.80	3.92	13.06	20 00

15. Miscellaneous Feeds.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	The Bennett & Millett Co., Gouverneur, N. Y.							
1174	Clover Meal. P. O'Blenis	Paterson	5.76	....	3.33	....	29.21	40 00
	Miner Hilliard Mill Co., Wilkesbarre, Pa.							
1230	Star Chop. F. C. Dunn	Hackensack	7.79	7.75	4.56	4.00	11.86	20 00
	E. P. Mueller, Chicago, Ill.							
1250	Sugar Beet Feed. Kyner & Looker	Boonton	8.24	10.77	0.83	1.16	19.15	15 00
	American Cereal Co., Chicago, Ill.							
1489	Hulled Oats. T. C. Dugan	New Brunswick	16.20	....	7.57	....	....	30 00
	The Hudnut Co., Terre Haute, Ind.							
1351	Maizeline. Sitley & Son	Camden	10.42	10.00	9.03	8.36	6.31	19 50
1369	Ground Oats. Taylor Bros	Camden	10.02	....	4.33	....	18.92	25 00
1511	Barley Meal. Thos. Eggert & Co	Perth Amboy	13.84	....	4.60	....	12.79	22 00
1045	Corn Meal. J. C. Ellett	Branchville	9.07	....	4.30	....	....	22 00
1104	*Cracked Corn. N. Dufford	Hackettstown	9.29	....	3.37	....	....	22 00
1207	Yellow Feed J. C. Smith & Wallace Co	Newark	7.79	7.50	3.39	3.00	7.69	19 00
1210	Company Feed. Wilkinson, Gaddis & Co	Newark	10.19	....	4.29	....	8.95	19 50
1211	Mixed Feed. Wilkinson, Gaddis & Co	Newark	8.76	....	3.87	....	5.17	18 00
1113	Rice Feed Pursel Milling and Coal Co	Phillipsburg	11.15	....	8.85	....	....	17 00
1298	Rice Feed. John D. Hoffman	Lebanon	10.71	....	10.02	....	....	20 00
1307	Mixed Feed (Tolls) W. H. H. Wyckoff	Raritan	9.62	....	3.86	....	3.37	18 60
1361	Rye Bran. C. H. Kirby	Medford	13.28	....	2.68	....	2.61	17 50
1362	Rye Middlings. C. H. Kirby	Medford	8.82	....	1.81	....	1.22	18 00
1506	Rye Feed. T. A. Ward	Freehold	9.00	....	1.88	....	1.70	23 00

*One-fourth heart removed in cracking.

LIBRARY

III. FEEDS MADE FROM WHOLE GRAINS.

1. Horse Feeds.

Sample Number.	MANUFACTURER AND PLACE OF SAMPLING.	Ingredients.	Protein.	Fat.	Crude Fiber.	Selling Price per Ton.
			%	%	%	
1293	G. N. Alpaugh, High Bridge	Corn, rye, oats	10.08	3.20	3.53	$21 00
1080	Warren Beatty, Hainesburg	Corn, rye, oats	9.61	3.48	4.63	22 00
1173	Belvidere Flour. Mill Co., Belvidere.	Corn, rye, oats	9.73	3.19	7.02	23 00
1149	*A. D. Cornell, Stillwater	Corn, rye, oats	9.82	3.13	3.79	22 00
1037	J. Crisman, Branchville	Corn, rye, oats	11.04	3.98	3.82	22 00
1087	G. H. Dorland, Blairstown	Corn, rye, oats	10.56	3.33	5.39	22 00
1102	Nelson Dufford, Hackettstown	Corn, rye, oats, corn ears	8.86	3.45	4.71	20 00
1038	†Eagle Flouring Mills, Ackermanville, Pa	Corn, rye, oats	9.93	3.55	4.60	22 00
1105	Geo. W. Fisher, Anderson	Corn, rye, oats	8.75	3.60	6.04	22 00
1274	‡Flemington Milling Co., Flemington	Oats, wheat	9.73	4.58	2.87	23 00
1090	E. J. Huff, Blairstown	Corn, rye, oats	9.29	2.73	3.72	22 00
1091	James Hutchinson, Delaware		10.46	4.16	2.75	20 00
1108	J. S. Hance, Hackettstown	Corn ears, rye, oats	8.75	2.88	7.92	22 00
1278	‡Higgins & Bros., Three Bridges	Corn, oats, wheat	10.13	4.28	2.63	23 00
1109	Wm. Larison, Washington	Corn ears, rye, oats	8.91	3.65	7.11	18 00
1043	McDanolds & Lance, Branchville	Corn, rye, oats	11.10	3.44	3.68	22 00
1112	Opdyke & Son, Washington	Corn ears, rye, oats	7.79	3.47	7.67	22 00
1116	Pursel Milling and Coal Co., Phillipsburg	Corn, rye, oats	11.42	4.71	4.02	22 00
1118	¶D. P. Reeves, New Hampton	Corn, rye, oats, corn ears	9.89	3.31	4.85	20 00
1096	W. H. Stires, Warrington	Corn ears, rye, oats	8.54	2.82	5.18	20 00
1119	S. Shillinger & Bro., Stewartsville	Corn, rye, oats	9.82	3.85	2.23	20 00
1193	J. C. Smith & Wallace Co., Newark	Corn, rye, oats	10.19	4.59	10.51	21 60
1264	††J. C. Smith & Wallace Co., Newark.	Corn, rye, oats	8.78	3.47	7.66	21 60
1190	M. M. Simonson, Newark	Corn, rye, oats	9.10	3.95	5.56	20 00
1098	§H. D. White & Son, Beattystown	Corn, rye, oats	11.95	3.84	4.51	22 00
1122	**Saml. Wildrick, Townsbury	Corn ears, rye, oats	8.76	3.12	6.01	22 00
1384	Saml. Anderson, Hammonton	Corn, oats, wheat	10.99	4.32	5.02	25 00
		Average	9.76	3.63	5.09	21 56

*Stock of Fold Bros., Sparta.
†Stock of S. Hill, Newton.
‡Stock of R. F. Hohenstein, Westfield.
¶Stock of J. M. Fitts, Washington.
††Stock of C. Pountney, Elizabeth.
§Stock of A. B. Albert, Danville.
**Stock of Empire Steel and Iron Co., Oxford.

III. FEEDS MADE FROM WHOLE GRAINS.

2. Corn and Oats.

Sample Number.	MANUFACTURER.	Place of Sampling.	Protein.	Fat.	Crude Fiber.	Selling Price per Ton.
			%	%	%	
1236	M. H. Acken, Rahway	Rahway	10.08	4.14	3.61	$22 00
1291	W. N. Adair, Raritan	Raritan	10.25	4.29	3.58	20 00
1241	Amerman's Mills, South Branch	Elizabeth	9.62	4.89	3.67	20 00
1442	P. E. Apgar, Weston	New Brunswick	10.01	4.75	2.18	20 00
1449	Henry Banker, New Brunswick	New Brunswick	9.56	4.24	3.07	20 00
1295	R. B. Beatty, North Branch	North Branch	10.42	4.42	5.17	18 00
1296	*R. B. Beatty, North Pranch	North Branch	8.80	3.90	6.36	16 00
1270	A. L. Cadmus, Plainfield	Plainfield	8.70	3.68	5.26	20 00
1199	A. Cyphers, Newark	Newark	9.51	4.18	2.80	22 00
1510	Thos. Eggert & Co., Perth Amboy	Perth Amboy	9.51	4.47	2.55	22 00
1409	*Fithian & Pennell, Bridgeton*	*Bridgeton*	*10.76*	5.14	3.95	22 00
1273	Flemington Milling Co., Flemington	Plainfield	8.70	4.22	3.10	20 50
1458	H. A. Ford, Allentown	Allentown	10.69	4.78	3.94	21 00
1275	C. Frank French, Plainfield	Plainfield	8.53	4.27	1.66	21 00
1512	R. Hance, Red Bank	Red Bank	10.13	4.72	3.15	24 00
1455	Higgins & Bros., Three Bridges	Three Bridges	9.79	4.57	2.27	20 00
1456	L. L. Holcombe, Flemington	Flemington	9.51	4.77	3.38	20 00
1414	J. T. Johnson, Bridgeton	Bridgeton	11.28	5.12	3.94	24 00
1462	G. H. Kirby, Allentown	Allentown	10.35	4.84	3.25	21 00
1046	G. Q. Moon & Co., Binghamton, N. Y	Branchville	7.90	3.83	7.60	21 00
1501	*David Neff, North Branch	North Branch	9.84	4.67	4.88	20 00
1257	The Paul T. Norton Co., Elizabeth	Elizabeth	9.28	4.54	5.41	19 40
1457	A. Rockafellow, Flemington	Flemington	9.45	4.53	1.81	20 00
1348	Sitley & Son, Camden	Camden	11.51	5.90	5.93	21 00
1501	C. H. Snyder & Son, Freehold	Freehold	9.23	4.51	5.88	23 00
1400	Taylor Bros., Camden	Hammonton	10.42	4.57	6.22	26 00
1305	E. S. Van Derveer, North Branch Depot	No. Branch Depot	9.16	3.96	2.44	18 00
1287	Van Zandt & Voorhees, Plainfield	Plainfield	9.39	4.24	3.85	21 00
1424	Vineland Grain Co., Vineland	Vineland	10.42	4.80	5.24	22 00
1504	T. A. Ward, Freehold	Freehold	9.90	4.59	3.03	24 00
1097	*H. D. White & Son, Beattystown	Danville	7.50	3.31	6.20	18 00
1507	J. P. Wyckoff, Manasquan	Manasquan	10.46	4.60	3.03	22 00
		Average	9.69	4.47	3.99	20 90

* Corn ears and oats.

III. FEEDS MADE FROM WHOLE GRAINS.

3. Corn Ear or Cob Meal.

Sample Number.	MANUFACTURER.	Place of Sampling.	Protein.	Fat.	Crude Fiber.	Selling Price per Ton.
			%	%	%	
1292	G. N. Alpaugh	High Bridge	7.44	3.52	5.87	$14 00
1294	R. B. Beatty	North Branch	8.01	3.83	4.25	15 00
1081	Belvidere Flouring Mill Co	Belvidere	6.87	3.34	8.20	16 00
1148	A. D. Cornell	Stillwater	8.93	3.36	4.75	15 00
1085	Thomas Craig	Buttzville	6.87	2.52	5.62	16 00
1101	Nelson Dufford	Hackettstown	7.21	3.58	6.47	17 00
1065	W. H. Ingersoll	Hamburg	7.90	3.65	6.82	15 00
1859	C. H. Kirby	Medford	9.39	4.26	3.94	16 50
1110	Wm. Larison	Washington	7.27	3.49	8.20	13 50
1802	David Neff	North Branch	7.79	3.44	5.93	15 00
1308	W. H. H. Wyckoff	Raritan	7.33	3.72	5.39	16 50
		Average	7.73	3.52	5.90	15 41

IV. POULTRY, STOCK AND CONDIMENTAL FOODS.

1. H. O. Poultry Feed.

Sample Number.	MANUFACTURER OR JOBBER AND DEALER.	Place of Sampling.	PROTEIN. Found.	PROTEIN. Guaranteed.	FAT. Found.	FAT. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	The H. O. Co., Buffalo, N. Y.		%	%	%	%	%	
1200	A. Cyphers	Newark	17.06	17.00	5.12	5.50	4.19	$30 00
1228	F. C. Dunn	Hackensack	17.18	17.00	5.92	5.50	5.08	35 00
1252	Jos. Benedict	Elizabeth	17.29	17.00	5.13	5.50	4.50	30 00
1335	J. S. Middleton	Camden	17.46	17.00	5.40	5.50	4.22	30 00
1311	J. E. Stevenson Co.	Trenton	16.94	17.00	5.89	5.50	4.87	30 00
1461	H. A. Ford	Allentown	18.00	17.00	5.82	5.50	5.48	29 00
1477	Hopkins & Lippincott	Moorestown	17.78	17.00	5.42	5.50	4.39	32 00
		Average	17.39	...	5.53	...	4.67	30 86

2. H. O. Scratching Feed.

	The H. O. Co., Buffalo, N. Y.							
1334	J. S. Middleton	Camden	12.25	...	4.65	...	...	35 00
1494	Colkitt & Thomson	Mount Holly	12.38	...	4.20	...	...	29 00

3. American Poultry Food.

	American Cereal Co., Chicago, Ill.							
1128	C. A. Wilson & Co.	Deckertown	12.70	18.96	6.51	5.49	4.69	26 00
1440	C. W. Russell	New Brunswick	13.28	18.96	6.62	5.49	4.79	30 00

4. Other Poultry Feeds.

1385	Old Fowl Mixture. Samuel Anderson	Hammonton	17.86	...	5.72	...	4.26	26 00
1489	Poultry Feed. Hopkins & Lippincott	Moorestown	18.23	...	9.11	...	7.46	30 00
1258	Poultry Feed. The Paul T. Norton Co.	Elizabeth	15.46	...	4.44	...	4.60	28 00
1546	Fidelity Food for Young Chicks. Pineland Incubator and Brooder Co	Jamesburg	19.85	20.47	6.67	8.68	...	...
1484	Wheat Screenings. W. Kimble	Rio Grande	12.94	...	5.89	...	4.12	18 00

5. Blatchford's Calf Meal.

	John W. Barwell, Waukegan, Ill.							
1189	C. A. Wilson & Co.	Deckertown	24.65	32.00	5.23	5.00	4.69	65 00
1242	Jos. Benedict	Elizabeth	25.08	32.00	5.42	5.00	4.94	70 00
1465	W. D. Rogers & Co.	Moorestown	24.98	32.00	5.22	5.00	4.36	70 00
		Average	24.90	...	5.29	...	4.66	68 33

IV. POULTRY, STOCK AND CONDIMENTAL FOODS.

6. American Calf Meal.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%	
1130	C. A. Wilson & Co.	Deckertown	18.01	17.37	7.73	6.67	2.70	$32 00
1810	J. E. Stevenson Co.	Trenton	16.83	17.37	8.29	6.67	1.94	50 00
		Average	17.44	....	8.01	....	2.32	41 00

7. Banner Stock Food.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Banner Food Co., Auburn, N. Y.							
1538	Hart & Iliff	Newton	22.81	....	8.40	....	....	160 00

8. Baum's Horse and Stock Feed.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	Baum's Castorine Co., Syracuse, N. Y.							
1853	C. H. Kirby	Medford	24.84	....	‡9.20	....	18.32	200 00

9. Animal Meal.

Sample Number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude Fiber.	Selling Price per Ton.
	The Bowker Co., Boston, Mass.							
1051	White Rock Lime and Cement Co.	McAfee	40.98	42.00	7.62	....	....	45 00
1243	Jos. Benedict	Elizabeth	43.05	30.00	8.52	5.00	....	45 00
1466	W. D. Rogers & Co.	Moorestown	42.13	....	8.79	....	....	50 00
1244	*Jos. Benedict	Elizabeth	53.59	30.00	14.92	20.00	....	50 00
	M. L. Shoemaker & Co., Philadelphia, Pa.							
1893	†Samuel Anderson	Hammonton	60.91	....	13.01	....	....	52 00

*Ground Beef Scrap.
†Ground Meat for Poultry.
‡Ether extract, incinding much sulphur.

GUARANTEES.

The object of the law in requiring the collection and analysis of the samples of feeds which have been herein reported, is primarily to determine to what extent the law has been observed and wherein it has been violated. A survey of the entire lot of samples which have been collected for this inspection develops the fact that of the 529 received, 118 are not required by the law to be guaranteed; of the 411 remaining, 331 were found guaranteed or guarantees have been filed at the Experiment Station, 5 were accompanied by a mere statement of the ingredients and 75 were devoid of any tag, statement or information of any character.

Of the 469 samples which have been analysed, the law does not require a guarantee in the case of 111. Sixty-four of the remaining 358 have no guarantees, although in a number of the horse feeds the ingredients were given; and of the 289 samples which have guarantees, 174 only are substantially as guaranteed. To state the situation in another form, of the samples which the law requires to be guaranteed and which have been analysed, 17.9 per cent. are not guaranteed at all and only 48.6 per cent. are guaranteed correctly. An inspection of the tables develops the fact that of the 115 samples which fail to reach guarantee, 67 are deficient in protein, 28 in fat and 20 in both of these nutrients. There are, therefore, among the 289 guaranteed samples 87 instances of a deficiency in the most important constituent of a purchased feed. A more detailed review of the deficiencies follows.

I. PROTEIN FEEDS.

Cottonseed Meal.

The thirty-seven samples of cottonseed meal were with one exception accompanied by a guarantee, which guarantee was uniformly 43 per cent. of protein and 9 per cent. of fat. The actual composition of the samples analysed is far from showing the same uniformity, since it ranges in protein from about 5 per cent. below guarantee in sample No. 1467 to about 5½ per cent. above in sample No. 1379 (if we except No. 1542, containing 51.49 per cent., a sample from old stock which perhaps does not represent the product at the present time), and in fat from 3.38 per cent. above guarantee in sample No. 1467 to 1.28 per cent. below in sample No. 1052. Of the thirty-six samples with guarantees, No. 1172, one of the American Cotton Oil Company's

eleven samples; No. 1502, one of the fifteen samples of the "Cofco" (Cotton Oil & Fiber Company's) brand, and Nos. 1330, 1467 and 1468, or all of the samples of the "Owl" brand (F. W. Brode & Company) are below guarantee in protein. No. 1330 is not materially below, but it is low in fat also, whereas Nos. 1467 and 1468 are high in fat content. Of the remaining thirty-one samples above guarantee in protein, five are materially below in their content of fat. The sample without guarantee, No. 1544 (Sledge & Wells Company), is lower in protein than the guarantee of the others. The remaining twenty-six samples are excellent in this respect.

Linseed Meal.

Of the sixty-eight samples of linseed meal, the forty-three samples of the American Linseed Company's goods were all accompanied by the uniform guarantee of 32 per cent. of protein and 5 per cent. of fat. The guarantee of fat is exceeded in every case, but in seven samples the content of protein is deficient by more than one-half of one per cent.

Of the remaining twenty-five samples, the nine of T. J. Preston and the three of Sitley & Son, are also guaranteed 32 per cent. of protein and 5 per cent. of fat, and all but one of Sitley & Son's exceed these guarantees. The one in question is 4.44 per cent. low in protein. But one other sample is guaranteed, the guarantee in this case being 40.96 of protein and 8.65 per cent. of fat. The sample contains, however, but 37.33 per cent. of protein and 8.07 per cent. of fat, indicating that it is quite as good in quality as any, but guaranteed too high.

The remaining twelve samples were not accompanied by any guarantee, as may be seen from the table. Among them are ten with sufficient percentages to more than meet a guarantee of 32 and 5. Two samples, however, No. 1232 of Titus, Wells & Willis, and No. 1262, of unknown source, and taken from the stock of C. Pountney, of Elizabeth, are low in their content of protein, the former containing 28.74 and the latter but 23.70 per cent. The former contains 9.28 per cent. and the latter 15.06 per cent. of fiber (woody matter), whereas linseed meal, on the average, contains but 7.3 per cent. In the case of the latter sample, at least, it would seem that there has been an admixture of foreign substance. The microscope reveals a substance having the appearance of ground corn cob, though such an adulterant of linseed meal has never been brought to our attention heretofore.

The samples of *Flaxseed Meal* are not required to be guaranteed, and none were so accompanied.

Gluten Meals and Feeds.

Six samples of *Chicago Gluten Meal* are reported with varying guarantees, one claiming 36 per cent. of protein, two 38 per cent., one 39 per cent., and two 39.50 per cent. The guarantee of fat is 3.30 in two instances and 3.37 in the others. These claims are practically fulfilled, except in the case of the fat of sample No. 1040, and in the case of the protein in samples Nos. 1018 and 1485, which have the guarantees of 39.50 per cent. As an explanation of the discrepancies it may be stated that the guarantees in the case of this product are computed on the supposition of an absolutely dry material. Nevertheless the law requires that the statement on the package shall show the percentage it (the feeding stuff contained therein) contains of crude fat and of crude protein. The Station, therefore, cannot undertake to re-calculate guarantees, even if the sample's actual content of moisture were furnished, which is not the case.

The three samples of *Davenport Gluten Feed* are quite uniform in composition and uniformly low in protein. The single sample of *Waukegan Gluten Feed* is also low in protein.

Sixteen samples of *Buffalo Gluten Feed* are reported, four of which were not accompanied by guarantees. The guarantees which were furnished vary from 27 to 28 per cent. of protein, and from 2 to 3.30 of fat. The analyses show that the guarantee of fat is either exceeded or practically fulfilled in every case. In regard to the protein, however, the same can be said in the case of only two of the twelve samples.

The four samples of *Rockford Diamond Gluten Feed* and the sample of *Marshalltown Gluten Feed* exceed their guarantees in both protein and fat.

Of the seven samples of the National Starch Manufacturing Company's *Gluten Feed*, only two are guaranteed, and one of these is deficient in both protein and fat. The two guarantees are quite dissimilar and the analyses of the samples indicate two grades, according to the two guarantees, viz., about 21 per cent. and about 28 per cent. of protein.

Two other *Gluten Feeds* appear in the tables, neither accompanied by a guarantee. In the case of No. 1340, the manufacturer is unknown; in the case of No. 1255, it was reported to be the Glucose Sugar Refining Company. This company, however, so far as our knowledge goes, puts out no brand of gluten feed as low as this one

Brewery Products.

Fifteen samples of *Dried Brewers' Grains* have been examined ; four were not guaranteed. Of the eleven with guarantees, five, the samples of the goods of J. C. Klauder, of Philadelphia, Pa., are found to be deficient in protein. It should be stated, however, that the guarantee of this brand of brewers' grains is placed unusually high without any corresponding increase in its price.

Twenty-three samples of *Malt Sprouts* have been examined ; eight have no guarantees at all, and one has a guarantee in protein only. Of the remainder, six are low in protein, viz., two of E. P. Mueller's six samples, both of Hottelet & Company's samples, one of M. G. Rankin & Company's two samples, and the sample No. 1370 of unknown manufacture.

Wheat Feeds.

Of the seven wheat feeds examined, three, those of the American Cereal Company's *Buckeye Feeds*, were accompanied by a guarantee. These samples all supplied the nutrients practically as guaranteed. The sixteen samples of *Wheat Bran* and the two samples of *Ship Stuff* do not require guarantees, nor do the wheat feeds when consisting of the unseparated bran and middlings from the manufacture of flour.

H. O. Dairy Feed and Germ Oil Meal.

The five samples of *H. O. Dairy Feed* were all accompanied by a guarantee, which in the case of the fat was uniformly too high. In the case of the protein, however, sample No. 1320 is the only one seriously deficient. The samples of *Germ Oil Meal* of the Cerealine Manufacturing Company were not accompanied by any guarantee. In most cases the dealers in cerealine feed reported that the slabs of unground cake were found in the car with the cerealine feed.

II. CARBOHYDRATE FEEDS.

Hominy Feed.

There are fifteen manufacturers of hominy feed represented by our samples. Of these, eleven furnish guarantees with thirteen brands, which in the majority of cases correctly represent their quality. In samples Nos. 1042, 1053, 1060 and 1167, there is a deficiency in protein, and in samples Nos. 1023 and 1192, a deficiency in fat. The remaining

seven brands have no guarantee whatever. They are average brands, however, with the exception of No. 1035, which is so deficient as to render it necessary to exclude it when computing the average. Upon investigation, it was found to contain 11.86 per cent. of fiber (woody matter), whereas average hominy feed contains 3.6 per cent. of this ingredient. It was acknowledged to be of inferior grade, on account of which it was sold at $18 instead of $19 per ton. It contains seventy-three hundredths of the average amount of protein, and sixty-six hundredths of the fat at ninety-five hundredths of the price.

Mixed Feed.

The eight samples of *Quaker Dairy Feed*, and the two samples of *Corn, Oats and Barley Feed*, all agree well with their guarantees. Likewise the twelve samples of *Victor Corn and Oats*, with the exception of No. 1213, which is slightly low in its protein.

The eight samples of *H. O. Horse Feed* are correct in guarantee of protein in every instance, but in the case of the fat the guarantees are too high in every instance, all but one sample being more than a quarter of a per cent. less than is guaranteed. The guaranteed amount is 4.50 per cent., and the average amount found 3.89 per cent.

Sugar Feed.

The five samples of corn bran or sugar feed of the Glucose Sugar Refining Company are correctly guaranteed in the case of protein, except in one instance, but the guarantee of fat is higher than the content of the same, except in one instance, and practically identical in another. In the sample of John Rankin & Company, the guarantee of fat is about one per cent. too high ; in that of Wm. T. Reynolds & Company, the guarantee of protein is too high, and in that of the Chas. Pope Glucose Company, both guarantees exceed the amounts found.

In the case of the four samples of the goods of Taylor Bros. there appears to be some confusion, two only being guaranteed, showing a shortage of protein in one instance, and great variations among the four.

Cerealine Feed.

The samples of cerealine feeds show quite a variation, both in composition and guarantee. The three samples guaranteed to contain 7.88 per cent. of protein, and 5.45 per cent. of fat, contain

practically these amounts. Sample No. 1331 contains more than the guaranteed 10.82 per cent. of protein and 7.57 per cent. of fat, but the four remaining samples fall short of supplying the 13.19 per cent. of protein guaranteed in two instances, and the 14 per cent. in the other two, although they do supply the amount of fat which is claimed.

Horse Feeds.

The twenty-two horse feeds which are not made from whole grains ground together, are required by law to be accompanied by a guarantee or a statement of their component parts. This is the case in all but five instances in all of which the promises are practically fulfilled.

Stock and Dairy Feeds.

Ten samples of *Chester Stock Feed* have been analysed. Eight are guaranteed to contain 11.50 per cent. of protein and 4.20 per cent. of fat, whereas the other two are guaranteed lower. In no case does the content of protein reach within several per cent. of that guaranteed, while in but three cases is the content of fat within a quarter of a per cent. of that guaranteed.

In the case of the samples of *Friend's Concentrated Dairy Feed*, not one of the four reaches its guarantee of protein and only one of the four its guarantee of fat.

Six additional *Dairy Feeds* are reported, of which three have guarantees and three have none. Of the three which have, two are deficient in protein.

Oat Feeds.

Eleven samples of oat feeds are reported, one of which was not accompanied by a guarantee. Of the ten remaining samples, there are only four which practically satisfy their guarantees, those which do not being two of the six samples of the Vim Oat Feed, both samples of Royal Feed, and two single samples of unknown manufacture. One of the three samples of *Oat Chop* is deficient in protein, being that of A. E. Howe, as is also the sample of *Durham Corn and Oat Feed.*

The analyses of eighteen samples of miscellaneous feeds follow in the tables, of which four are accompanied by guarantees, which are found to be correct, except in the case of the protein of the *Sugar Beet Feed.* Of the remaining fourteen samples, the clover meal, hulled oats, ground

oats, corn meal, rye bran, rye middlings and the mixed feed, consisting of the accumulation of millers' tolls (pure grains ground together), are exempt. The remainder should be guaranteed.

III. FEEDS MADE FROM WHOLE GRAINS.

The feeds made from whole grains, or from materials in their natural state, are not required to be accompanied by a guarantee. They include: (1) The horse feeds, (2) corn and oats, and (3) corn ear or "cob" meal. Nevertheless, an inspection of these goods, and in fact of all feeds, is authorized by the law.

IV. POULTRY, STOCK AND CONDIMENTAL FOODS.

A few of each of these feeds have been examined. The poultry feeds are all foods simply — that is, they supply nourishment, whereas the calf meals and other foods for animals are medicinal as well.

Of the *Poultry Feeds*, the H. O. Feed is in every case substantially as guaranteed, except in the fat of two samples, and the American Poultry Food is low in protein in both of the samples. The sample of Fidelity Food for Young Chicks is likewise low in protein. Of the remaining poultry feeds, the H. O. Scratching Feed and the Wheat Screenings, being whole grains, are not required to be guaranteed. The other three are derelict in this respect.

Of the *Stock Foods*, the three samples of Blatchford's Calf Meal are all deficient in protein guaranteed, the two samples of American Calf Meal have guarantees snbstantially correct, and the sample, each, of Banner Stock Food and Baum's Horse and Stock Feed were accompanied by no guarantee whatever.

A few samples of ground meat scrap, etc., were collected. Upon examination, they were fonnd either unguaranteed or with guarantees very wide from the actual content, as, for example, in the case of sample No. 1244, guaranteed to contain 30 per cent. of protein and 20 per cent. of fat, and actually containing 53.59 per cent. and 14.92 per cent., respectively, of these ingredients.

THE ACTUAL COMPOSITION.

The fact that certain feeds do or do not furnish the nutrients as guaranteed is not the only point of interest in the examination of a lot of feeds such as has here been reported. The average reader will

inquire why there should be so many feeds of such different composition, and why should guarantees be required. In answer to such questioning, it has been deemed that a brief discussion of the origin of these feeds and of their actual composition may perhaps prove interesting at least, if not helpful in their purchase and use. As stated before, the feeds which are characterized by a high percentage of protein are classified together as the protein feeds, and, similarly, those containing little protein and considerable carbohydrates are called the carbohydrate feeds. Protein is the flesh-forming constituent, and might be called the lean meat of the animal's dinner. The carbohydrates, on the other hand, are the fat-forming constituents, and consist either of fat itself or of starch, sugar, or some kindred product, which, when eaten by the animal, goes toward the production of fat or maintains the animal in weight and warmth, while performing, with the assistance of the protein, the work or other purpose for which it is kept. Scientific investigation of actual practice has disclosed the fact that the best results are obtained when, under equal conditions, certain definite proportions of protein are present in the food. This proportion is called the "nutritive ratio." To secure the proper nutritive ratio for the purpose in hand, protein feeds and carbohydrate feeds must be mixed together, and, except when more progressive practice obtains, most farm products are carbohydrate feeds.

PROTEIN FEEDS.

All seeds or grains naturally contain certain amounts of protein and carbohydrates, and either whole or ground, are fed to the animals of the farm, as when corn is fed to cattle or oats to horses. But man has found that certain portions only of the grains are pleasing to his own taste or useful in his arts and manufactures. By machinery or other manipulation, therefore, he separates the portions which he desires and leaves the remainder for his cattle.

Probably the most familiar practice of this description is the grinding of wheat. The softer starchy portions are separated as flour, and the bran and middlings are left to form protein feeds of great value in the feeding of animals. The manufacture of starch, and of glucose, which is made from starch, likewise abstracts from corn the most of its carbohydrates, leaving a residue which is ground up to form a gluten feed. In the manufacture of beer and whisky, the starch is likewise abstracted for fermentation, and the exhausted brewers' or

distillers' grains, when dried to prevent further fermentation, form another feed rich in protein.

On the other hand, the oils of seeds in many instances are of great value in the arts, and, being removed by pressure or other process, leave residues rich in protein, as, for example, the linseed meal from the manufacture of linseed oil.

These residues, it must be clearly understood, are identical, so far as they go, with the natural product from which they are formed. The protein in linseed meal is identical with that in the flaxseed; the fat or oil has merely been removed. It is just as if one should squeeze a lemon, retaining the skin in one's hand; the portion remaining in the hand would be lemon skin still, and mostly lemon skin. The protein in dried brewers' grains is the protein of the barley grain, and the protein of gluten meal is the protein of the corn kernel, just as much as the protein of wheat bran is the protein of the crushed wheat, or of the whole grain. The only difference is that it is concentrated, and hence there is more of it in a given weight, or, in other words, it is there in a higher percentage, and as the process to which each has been subjected is more or less uniformly perfect, so will the product be more or less concentrated, and more or less constant in composition. With these points in view, the origin, composition and uniformity of the different feeds will be discussed.

Cottonseed Meal.

The seed of the cotton plant is cleaned from the adhering portions of cotton fiber, and the black shell-like hull removed (*i. e.*, the seed is decorticated), after which the kernel or meat is cooked and exposed to pressure to express the oil. The residuary slabs of cottonseed cake are pulverized to form the bright yellow cottonseed meal of commerce. Several imperfections in the process may operate in producing variableness in the protein of the product, viz., an imperfect removal of the lint, or of the hulls, or of the oil. Any of these would reduce the content of protein. The last shows itself on analysis when a low content of protein is accompanied by a high content of fat; the second is apparent from the meal's darker color, except when the first also occurs, for then the yellow meal is entangled in the lint, which adheres to the hull, so as to hide the presence of the latter, except from a minute examination. The samples examined this year *are mainly of good quality, thirty-one out of thirty-seven equaling or*

exceeding 43 per cent. of protein, and the entire number averaging 45.71 per cent. of protein and 9.48 per cent. of fat. The range in protein is from 38.03 per cent. to 48.55 per cent., or over 10½ per cent. There are many feeds whose total content of protein is less than this variation in cottonseed. Perhaps it is impossible to secure a more uniform product than this, and as long as the actual composition exceeds the modest guarantee which has been fixed, there is no room for complaint.

Linseed Meal.

This product is similar in its origin to cottonseed meal, in that it is made by grinding the cake, which is left after pressing out the linseed oil from flaxseed, and hence it is often called "Cake Meal." This process, which is the "old process," admits of a variability due to imperfect removal of the oil. The new process of removing the fat is by extracting with naphtha, benzine, or a similar solvent of oily matter. This removes more of the fat, and hence the "new process" meal is richer in protein, and poorer in fat than the "old process" meal. The samples analysed ranged from 27.56 to 37.67 per cent. of protein, or a difference of 10.11 per cent. The average analysis of all of them is 33.30 per cent. As long as they exceed their guarantees, however, no criticism can be made. The adulteration of sample No. 1262 has already been noticed, and the sample is therefore disregarded, in considering the rariability in composition.

Flaxseed Meal.

The analyses of flaxseed meal show much greater fluctuations than would be expected in a material which had received no other treatment except grinding. Three of the samples contain so much less of both protein and fat than is usual that it was necessary to exclude them from the average.

The Gluten Products.

Gluten meal and the gluten feeds are the residues, or parts of the residues, from the manufacture of starch and glucose. This subject was studied and reported in 1894, from the report of which year much of the following is an abstract. The processes by which the starch is obtained, while perhaps differing somewhat, consist essentially in the separation, first, of the germ and hull from the starch

and gluten; and second, the final separation of the gluten from the starch, which is effected by allowing the fluid in which they are suspended to flow through long troughs, the heavier starch settling to the bottom, and the lighter yellow substance, containing the protein and fat, floating off.

The residue in this manufacture may, therefore, consist either of three products when the gluten, germs and hulls are kept separate, or of mixtures of two or of all three of these. In any case, however, the feeds are parts of the original corn, though when dried for market they differ in appearance, in proportion of food constituents, and in physical character.

The entire residue mixed together is in color a brighter yellow than corn meal, and of a much more bulky character, owing to the presence of a larger proportion of the bran; the trade name of this product is "Gluten Feed." The gluten, by itself, is distinguished by a higher content of protein and a deeper yellow color, and is called "Gluten Meal." The germ is more bulky than the meals, shows a high content of crude fat and is called "Germ Meal." The fat is sometimes extracted, when, similarly to linseed meal, the residue is called "Germ Oil Cake," and, when ground, "Germ Oil Meal." The hulls are very bulky, show a high content of crude fiber, and, either alone or with the germ, are sold as "Corn Bran" or "Sugar Feed."

The Chicago Gluten Meal appears from analysis to be the only case of the gluten being sold separate from the other portions of the residue. The samples analysed contain, on the average, 37.60 per cent. of protein and 3.91 per cent. of fat, and range from 35.43 to 38.95 per cent. of protein and from 2.50 to 6.13 per cent. of fat. The gradual increase in the protein is accompanied in a practically systematic manner by a diminution in the fat, showing that the variations are mainly due to imperfections in the separations.

The remaining gluten feeds are evidently the mixed residues of manufacture. The Davenport Gluten Feed is quite uniform and averages 24.39 per cent. of protein and 3.75 per cent of fat, the Buffalo Gluten Feed averages 26.51 per cent. of protein and 3.60 of fat, the Rockford Diamond Gluten Feed averages 27.32 per cent. of protein and 3.34 per cent. of fat, and the Marshalltown Gluten Feed (of which we have but a single sample) contains 29.20 per cent. of protein and 3.44 per cent. of fat. All these are the output of factories of the Glucose Sugar Refining Company. The Waukegan Gluten

Meal of the United States Sugar Refining Company, of Waukegan, Ill., contains 26.36 per cent. of protein and 4.34 per cent of fat, while the samples of the National Starch Manufacturing Company's Gluten Feed apparently fall into two grades, containing on the average, respectively, 28.61 and 22.24 per cent. of protein and 4.13 and 3.74 per cent. of fat.

Brewery Products.

The brewery products are the dried brewers' grains and the malt sprouts. In the manufacture of beer the barley is first caused to sprout, since the growth of the sprout causes a change of the starch into sugar. The sprouts are then removed, and the grain, with its insoluble starch changed into soluble sugar, is soaked in water, which dissolves the sugar and in addition a small portion of the other ingredients. It is this sweet solution that is fermented to form beer. The sprouts and the spent grains are sold as cattle food, the latter sometimes in the wet condition, when they are liable to sour, and hence are rarely used thus except in the immediate locality of the brewery. For storage or long shipment they are dried, and in this condition are found in the feed stores.

In the manufacture of whisky, also, the same process takes place, but in this case the grains are, in addition, rye, wheat or corn. These grains are sometimes added in the manufacture of ale and beer, which might account in part for the variability of the different brands, were it not that through other causes the samples of one brand occasionally differ among themselves more than do the different brands themselves. These causes are imperfect drying, over-drying and scorching and delay in drying until souring has set in. The first leaves too much moisture in the material, the second destroys a part of the substance and imparts a burnt odor, and the third destroys substance and imparts more or less offensive odor. Properly-dried grains should have a peculiar, nutty odor, that is pleasant and appetizing.

The samples of dried brewers' grains which have been analysed this year are comparatively uniform in composition, ranging from 21.49 to 29.24 per cent. in protein, and from 6.90 to 9.24 per cent. in fat. The average is 25.57 per cent. of protein and 7.74 per cent. of fat, all of which is undoubtedly of practically the same efficiency and value as if contained in the original barley or other grain from which it came.

The malt sprouts range in composition from 22.79 to 30.23 per cent. of protein and from 1.44 to 3.70 per cent. of fat, and average 25.59 per cent. of protein and 2.59 per cent. of fat. In the case of the malt sprouts, about one-fourth of the crude protein is not in the form of albuminoids, which is considered the more valuable form of the protein compounds. It must be remembered that these young sprouts are very tender forms of vegetable growth, and are, therefore, highly digestible. The nutrients in them may be likened, therefore, to those of the young and tender pasture grasses in the spring.

The Wheat Feeds.

The wheat feeds in the tables are very similar in analysis to the wheat brans, but differ in not being separated, as completely at least, from the middlings. Wheat feeds may or may not contain an admixture of other grains or feeds. No statement to this effect has been received.

It is assumed that the wheat products are familiar to all feeders, and it need only be added that the same division and concentration takes place in them in making flour as takes place in the corn products in the glucose or starch manufacture. Thus there is about four times as much fat and about one-third more protein and considerable less starch in the whole wheat than in the manufactured flour. In the flour the starch has been concentrated, and in the by-products it has been excluded and the gluten and fat concentrated. This concentration is greater or less as the separation is more or less thorough. Thus the bran is richer in protein and fat than the flour; the middlings differ according as they contain more or less of the exterior parts of the grain or of the softer, starchy portions of the kernel; and middlings, for the same reason, vary from the coarser kinds through all the fancy grades up to what is known as Red Dog flour, which may be regarded either as a flour or as a middlings.

It will be noticed that there is a variation in the composition of the wheat products reported in the table. This may be due to various causes, among which may be mentioned the variation in the original wheat (spring, winter, western, local, etc.), and the variation in the process—the new roller process yielding a bran with a higher content of protein than the old milling process. The new process bran, therefore, is of greater effect in compounding rations, but many regard the old process bran as of superior digestibility.

CARBOHYDRATE FEEDS.

As distinguished from the protein feeds, the carbohydrate feeds are characterized by a high content of the starchy and similar elements of the grains, and consequently a lower content of crude protein. The two main sources of the carhohydrate feeds are corn and oats. Corn is itself a carhohydrate feed, but in the manufacture of starch or glucose, the carbohydrates have been removed so thoroughly that the residues contain the protein in such amounts as to carry them into the protein class. In the manufacture of hominy and cerealine, the separation of the starchy portions of the grain from the glutinous portions is not so perfect, and the resulting residue is still high in carbohydrates and relatively low in protein. On the other hand, the manufacture of oats into cereal food for man does not consist in the separation of carbohydrates from protein, but rather in a cleaning of the oats and a selection of the large, plump grains. The residues of this manufacture, consisting of the hulls and the light oats are, therefore, diminished in protein content to such an extent as to carry them into the carbohydrate class. Some manufacturers, aware of this depreciation, restore the protein by a judicious addition of other feeds, in some cases to such an extent as to carry the mixture into the protein class.

THE OATS PRODUCTS.

H. O. Dairy Feed.

This feed is undoubtedly an example of the fact just stated, since under the microscope it is revealed to consist of oats, corn, wheat and cottonseed meal. Oats contain on the average about 12 per cent. of protein, 5 per cent. of fat and 9½ per cent. of fiber. Oat hulls, on the other hand, contain as low as 3¼ per cent. of protein and 1 per cent. of fat, and as high as 29 per cent. of fiber. The inferiority of the hulls, as compared with the whole grain, may be thus seen, as well as the fact that the fiber is a characteristic of the hulls, and the presence of hulls is practically demonstrated by the presence of fiber. The light oats and hulls of an oatmeal factory probably have a composition somewhat between these extremes, possibly that of the "oat feed" of commerce. In the samples analysed, the addition of cottonseed meal and wheat bran has raised the content of protein to exceed that of oats by one-half more, and carry the mixture into the

protein class, among which materials it will be found, properly tabulated. The character of its base (light oats) is shown, however, by the percentage of crude fiber it still contains. These feeds are guaranteed to contain 18 per cent. of protein, and 4½ per cent. of fat, and actually contain (on the average) 18.42 per cent. and 3.85 per cent. respectively, with, in addition, 12.75 per cent. of fiber.

It should be stated here that there is no intention on the part of this Station to disparage any goods or class of goods, because of the presence of an excess of oat hulls. Although probably of no greater value than the coarsest grades of fodder they are a legitimate article of commerce, and, besides, are considered by many authorities as of value in adding bulk to the ration. It is when mixed feeds, which contain oat hulls, are sold without guarantee or statement of any kind, and the hulls are used to create the appearance of oats, that deception and fraud enter.

Quaker Dairy Feed.

This feed is another outlet for the light oats of an oatmeal factory, the assisting grain being wheat. The guarantees of this brand of goods are placed at 12.03 per cent. of protein and 2.50 per cent. of fat, and the average content is 13.19 per cent. and 3.22 per cent. of these nutrients respectively. The guarantee, as well as the composition, indicates the addition of less protein-bearing material, and the content of fiber is consequently not reduced to less than an average of 17.64 per cent.

Victor Corn and Oat Feed.

In this brand there is evidently a much smaller proportion of the oat products. On the other hand, there appears to be no addition of a protein feed. The guarantee is 8.23 per cent. of protein, and 3 per cent. of fat, and the average composition 8.73 per cent. of protein and 4.09 per cent. of fat. In the *Corn, Oat and Barley Feed* the addition of the barley has raised the percentages of the protein and fat.

H. O. Horse Feed.

This feed is similar to the H. O. Dairy Feed, except that linseed instead of cottonseed meal is used with corn and wheat as the materials to build up the feed. It is evidently the intention of the manufacturer to imitate the composition of oats, since the average

composition is 12.61 per cent. of protein, 3.89 per cent. of fat, and 9.63 per cent. of fiber. The content of fat falls below that intended, and also below that in oats; otherwise the attempt is quite successful.

Chester Stock Food.

In this feed there is no indication that more than a small portion consists of light oats or of anything else than oats and corn. The content of fiber (11.11 per cent.) is low for this class of goods, whereas the protein is about where it should be if normal oats were mixed with corn meal. The reduction of the fat below the fat content of either corn or oats would indicate that some light oats or other low grade product was used. The chief criticism to be made of this brand is that it fails absolutely to meet its guarantee; the actual content is 7.43 per cent. of protein and 3.36 per cent. of fat, whereas the guarantee of the most of the samples is 11.50 per cent. of protein and 4.20 per cent. of fat.

Friend's Concentrated Dairy Feed.

This brand is concentrated in fiber chiefly; its composition is not far from that of the oat feeds, and indicates that the material is mostly light oats with a little corn. This brand also fails to meet its promises of 10.70 per cent. of protein, and 3.70 per cent. of fat, since it contains on the average but 7.98 per cent. of the former and 3.39 of the latter. Its content of fiber is 22.18 per cent.

Other Feeds.

The analyses of a few other feeds appear in the tables, ranging from 7.47 to 12.48 per cent. of protein, 2.80 to 7.42 per cent. of fat and from 5.29 to 14.89 per cent of fiber. The same considerations and conclusions apply here as in the preceding cases.

Oat Feeds.

Fourteen samples of oat feed and oat chop were also analysed. These appear to be oat hulls almost exclusively, the content of fiber ranging from 21.53 to 32.41 per cent. The guarantees, also, in every case except a few of the samples of Vim Feed, are erroneous in some particular.

CORN PRODUCTS.

The corn products, as previously indicated, are the hominy meals from the manufacture of hominy, the cerealine feeds from the manufacture of cerealine and the sugar feed from the starch and glucose industry. The origin of *sugar feed* has been described in the discussion on gluten meal, with which it is allied. This product is in most cases richer in protein than the original corn, but not sufficiently so to be classed as a protein feed. It contains about the same amount of fat as corn meal, together with considerable fiber. The separation of the carbohydrates is accountable for this concentration. In the manufacture of *cerealine feed* and of *hominy meal* the separation is not as complete; for this reason the content of protein is slightly advanced and the fat more so, especially in the case of the hominy meal.

Horse Feeds.

The analyses of twenty-two samples of *horse feeds not made from whole grains* appear in tabulated form. A few of these feeds were not guaranteed, almost all of them being accompanied by at least a statement of their ingredients. The average content of protein is 10.38 per cent., of fat, 4.66 per cent., and of fiber, 5.22 per cent. These feeds are mainly the product of New Jersey mills, and for local consumption, with a comparatively small sale. The difficulty, or rather, inconvenience, in formulating guarantees for these products arises from the fact that the proportions of their ingredients and the ingredients themselves are changed as the market changes from time to time. That this necessarily leaves the consumer in the dark as to their composition is an additional reason why they should be accompanied by a statement of their component parts, if not by a regular guaranteed analysis.

In the case of the *horse feeds made from whole grains*, and hence not required to be guaranteed, the same fluctuation of ingredients is apt to occur. Frequently the collector of feeds was informed that "we are not putting in so much —— as usual, because it has gone so high." These horse feeds were, however, of very uniform quality when all is considered, ranging in protein from 7.79 to 11.42 per cent., in fat from 2.73 to 4.71 per cent., and in fiber from 2.23 to 7.92 per cent.

Corn and Oats.

The analyses of the thirty-two samples of corn and oats indicate a very good quality for the "provender" of the State. There is no indication of any but a limited use of extremely light oats, and in only a few cases does the content of protein fall below that of corn meal. Corn ear meal, or cob meal has been used in a number of instances, and in most of them the fact was stated. The possibility of changes in the proportions of corn and oats from time to time is a disadvantage in the purchase of corn and oats ground together.

Corn Ear or Cob Meal.

Eleven samples have been analysed, with quite uniform results. The protein ranges from 6.87 to 9.39 per cent., the fat from 2.52 to 4.26 per cent., and the fiber from 3.94 to 8.20 per cent.

POULTRY STOCK AND CONDIMENTAL FOODS.

A few samples only of feeds of this character have been collected by this Station. In regard to the *Poultry Feeds*, there is no indication that they consist of anything else but a mixture of the usual materials known to be of value in the feeding of poultry. They all contain grains of recognized value. A little charcoal has been added to the H. O. Scratching Feed, some meat is apparently contained in Hopkins and Lippincott's Poultry Feed, and meat, charcoal and limestone seem to be associated with the grains which compose Fidelity Food for Young Chicks. Unless these additions are taken into account, there is no apparent reason why any of these mixtures should command a price so much higher than that for which practically the same ingredients may be bought in the ordinary cattle mixtures, not to mention their purchase in the form of grain separately. It clearly is possible for any poultry farmer to purchase charcoal, lime, meat scrap, etc., to mix with wheat screenings or other food to form a good poultry ration. These ingredients are to be found in the feed stores, especially in the districts where much poultry raising obtains. Nevertheless, for the *average* farmer it is a great convenience to be able to purchase a poultry ration ready made, for thereby he avoids the selection and storing and subsequent assembling of a lot of materials of limited use in the small quantities he would need to buy. This convenience, perhaps, offsets the increased cost.

In the case of the *Stock Foods*, the same considerations in regard to the price apply to a large degree, for in many cases the increased price seems occasioned by the addition of small quantities of material which are foreign to feeds. To be sure, they are understood to be of a medicinal or stimulating nature, and are claimed to be particularly effective and valuable, not only for growing animals, but also for cows in milk and for horses. The Station believes that healthy animals need no medicine or stimulant; stock-raisers and dairymen should know sufficiently of the common ailments of their animals to prescribe intelligently the more common and *known* remedies, and for sickness of a serious character a skillful veterinarian should be called in.

The small package in which most of these foods are put up is responsible, in large part, for the enhancement of the selling price reported in the tables, since ton prices have been calculated from package prices; but, even so, when a mixture is sold at the rate of $200 per ton it is evident that the inventor is being well paid for devising it, as well as the manufacturer for mixing it. It is fortunate that in most of these expensive preparations the directions call for the use of very small quantities.

SELLING PRICES.

The dealers' selling prices for the different materials, of which samples have been taken, were either noted at the time or secured later by correspondence. These have been entered in the tables not so much for the information of consumers as that the average prices might be computed for the period during which samples were collected. The individual prices cannot fairly be compared with each other, for the samples were gathered during a fluctuating market, but as samples of all kinds were constantly being taken whenever found, it is believed that a comparison of averages is permissible, and the average prices, therefore, have been included in the table of averages, which appears earlier in this bulletin.

An inspection of the prices of the individual samples shows that notwithstanding the fluctuations in the price of feeding stuffs, the price of *cottonseed meal* was never very far from the average, $28.70. *Linseed meal*, apparently, is quite the contrary in this respect, but the greater part of the abnormally high prices per ton are calculated from the dealers' prices for very small lots—as small in some instances as the pound. Linseed meal, under these circumstances,

is used for probably no other purpose than stuffing horses' feet, etc. Omitting such cases from consideration, the price of linseed meal was not far from the average at any time, *i. e.*, $34.08. For reasons similar to those applying to linseed meal, the prices of flaxseed meal have not been averaged.

The *glutens* have been extremely uniform in price, the higher gluten (Chicago), with an average content of 37.60 per cent. of protein, selling at the higher average price ($26.08).

The remaining feeds in the tables, furnishing protein in percentages ranging from 29.20 in Marshalltown Gluten Feed to considerably under 10.00 in certain mixed feeds, deviate very little from a uniform price of $20 per ton. An inspection of the table of averages in an earlier portion of this section will reveal the fact, if such may be termed a revelation, that quality and price by no means go hand in hand. This is the case if we consider the content of protein as the guide to quality, or if we inspect the table with an eye to the general analysis.

It is very much to be regretted that the present state of our knowledge does not admit of the placing of a valuation in dollars and cents upon the various feeds contained in the tables. Such a procedure would yield results of great practical utility to feeders and of considerable general interest as well. This is possible and is the practice with commercial fertilizers, but is impracticable with feeds. Artificial fertilizers are mixtures of raw materials, of which each supplies (as a rule) but one of the essential forms of plant food. From the price of the raw material the cost of its particular valuable ingredient can readily be determined, and this value is applicable to that ingredient wherever found. On the other hand, feeds are not artificial. In their simplest and natural forms they are nature's mixtures of water, mineral matter, protein, fat, fiber and carbohydrates. They are naturally complex materials, and the situation is further complicated by the fact that their component parts—the protein, fat, etc., in the various feeds—are in varying proportions and of varying digestibility.

The Selection of Feeds.

Not having an estimated comparitive valuation upon which to base a choice of feeds, it becomes necessary for the feeder to use a wise discrimination, based on a sufficient knowledge of feeds in general and animals in particular, to which must be added a good business sense.

The feeder should know the character of the feeds the purchase of which is under consideration. If he is well informed, the trade name will indicate its composition in a general way. If the feeds are subject to the provisions of the law, the furnished guaranteed analysis will inform him which of them are claimed to be rich in protein and which are largely carbohydrates, and the publication of the analyses of the feeds by the Experiment Station will show to what extent these claims are substantiated.

From his knowledge of feeding stuffs, also, he should know, at least approximately, the analysis of the materials which he has on hand. Home-grown fodders and feeding stuffs, which form the foundation upon which the farmer builds his ration, usually furnish all the carbohydrates and fat, but rarely all the protein needed. *From an account of stock on hand he should determine his needs*; if for protein, buy accordingly, for further accumulation of carbohydrates is unnecessary and wasteful.

After this is determined there comes the selection of the feed which carries the needed nutrient. All feeds are not equally digestible. Gluten meal is more digestible than either linseed or cottonseed; rye meal and barley are more digestible than wheat bran or middlings. And yet the linseed, cottonseed, wheat bran and middlings should not be dropped from use. There is a greater adaptability of certain feeds to the needs of particular animals. Poultry and swine do not relish or do well on cottonseed meal. The feed must be selected so that the ration may be palatable. When animals do not like their food they do not do well. A variety of materials must be furnished, and the fodders and feeds must be so combined as to use them up during the season and still avoid the exclusive use of one or two kinds for any extended period of time.

Nevertheless, the feeder must use his business sense. When oats and corn are both hovering around $24 per ton there is no combination of pure grains that can be made which will yield the manufacturer a profit at $18 per ton. If protein feeds are desired, consider content of protein and price per ton together in the selection. The protein feeds are submitted in a wide variety, and, this year at least, the differences seem to be in analysis rather than in price.

When home-grown feed commands a high price, sell and buy cheaper feeds. In many instances the purse and the ration are both improved. If corn is high and, therefore, to be sold, and gluten meal is bought in its place, the best of the corn is brought home again. It is a common practice to exchange wheat for wheat bran;

why not corn for gluten meal or feed? Still, this is not applicable to all feeds; for while an exchange of corn for gluten products returns the best of the corn, the exchange of oats for oat feed returns the poorest portions of the oats.

On the other hand, the home-grown products may be cheap, and there is a point when the exchange, though desirable from the standpoint of the ration, will not prove profitable enough to warrant itself. Remoteness from market, the price of feeds, the freight rates and the small returns from dairy products may so change conditions as to render one feeder's folly, in feeding carbohydrates wastefully, the most profitable, if not the most desirable, course for another feeder to pursue.

All these things must be borne in mind by the feeder who would be successful. When buying, buy wisely. Buy either standard goods, the quality of which may be judged pretty accurately, or insist on guarantees. Avoid the materials which are marked down because they are slightly below grade. Usually the reduction in price is by no means large enough, and having accepted the goods with the statement that they are damaged or deficient, there is no redress.

Of course it must be remembered that certain products are exempted from the provisions of the law, as stated in the opening pages of this section. As to the others, the Station expects to do its duty in the matter. In the fertilizer inspection it has been found that the desire to stand well in the published results of the inspection has been an important factor in causing a careful attention to legal provisions. At the same time, those who find it necessary to purchase feeding stuffs should remember that they can largely assist in determining the extent to which the law is obeyed. If they refuse to buy goods not properly marked or for which no guaranteed analysis can be furnished, when under the law such should be furnished, dealers will not handle such goods; and when dealers refuse to handle a particular brand, the manufacturer will be obliged to comply with the law to protect his interests.

III.

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Since the establishment of this Station in 1880, a large number of analyses of fodders and feeds have been made in its laboratory. The results of these analyses, showing the composition of the different samples and variations in the composition of materials of the same kind, have appeared from year to year in the reports of this Station, accompanied by such comments and explanations as were deemed necessary.

The following tables of analyses have been compiled for convenience of use and as a guide to the composition of the fodders grown in this State, and the feeds for sale in its markets. The tables include 1,251 analyses, representing 176 different kinds of fodders and feeds. Differences in composition are observed between those fodders grown upon soils in a good state of fertility and rich in organic matter, and those grown on light and sandy soils ; in nearly every case the former are richer in fat and protein. Great differences are likely to occur, also, if hay, corn fodder, straw, etc., are not cut at the proper time, or not gathered in good condition. The feeds, on the other hand, when properly classified, are reasonably uniform in composition. While these averages are therefore trustworthy in the majority of cases, judgment must be exercised when products used are known to be either extra good or very poor.

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Number of Analyses.		Pounds per Hundred.								
		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen—Free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
	GREEN FODDER.									
	Cereal Grasses.									
23	Corn (Maize)	74.8	0.5	5.8	1.7	1.6	15.6	0.28	0.18	0.83
1	Leaming Corn	76.4	0.6	4.9	1.9	1.0	15.2	0.30	0.13	0.32
1	Red Kaffir Corn	81.6	0.6	4.8	1.8	1.3	9.9	0.29	0.18	0.45
1	White Kaffir Corn	83.4	0.7	4.6	1.9	1.4	8.0	0.30	0.12	0.50
1	White Thoroughbred Corn	80.3	0.6	3.8	1.7	0.9	12.7	0.26	0.12	0.28
1	Southern White Corn	78.5	1.0	5.3	1.5	1.0	17.7	0.24	0.10	0.24
1	Evergreen Broom Corn	77.1	0·5	8.6	2.0	1.7	10.1	0.32	0.17	0.70
1	Stowel Evergreen Corn	77.9	0.6	4.5	1.8	1.2	14.0	0.28	0.14	0.38
1	Teosinte	90.1	0.3	2.7	1.4	1.4	4.1	0.28	0.05	0.66
1	Rural Branching Doura	85.9	0.4	4.7	1.7	1.3	6.0	0.28	0.15	0.46
1	Yellow Millo Maize	83.2	0.6	5.5	1.7	1.5	7.6	0.27	0.11	0.57
9	Rye	77.0	0.6	10.1	2.3	1.9	8.1	0.37	0.24	0.64
3	Sorghum	72.6	0.3	6.2	0.8	1.0	19.1	0.13	0.05	0.19
2	Sugar Cane	84.2	0.5	4.0	1.2	1.1	9.0	0.20	0.09	0.44
2	Japan Millet	79.8	0.6	5.7	2.0	1.9	10.0	0.32	0.16	0.65
1	Japan Broom Corn Millet	77.4	0.9	6.2	4.0	2.4	9.1	0.64	0.16	0.73
3	Barnyard Millet	82.7	0.6	4.9	1.5	1.5	8.8	0.23	0.11	0.49
1	Pearl Millet	83.0	0.4	5.5	1.1	1.7	8.3	0.18	0.15	0.71
1	Barley	81.7	0.9	4.2	2.9	1.7	8.6	0.46	0.10	0.54
7	Pasture Grass	63.1	1.5	7.4	5.6	3.2	19.2	0.90	0.26	0.74
1	Wheat	77.3	0.7	5.9	2.4	1.8	11.9	0.38	0.16	0.60
	Legumes.									
3	Red Clover	71.9	0.8	8.4	3.0	3.5	12.4	0.48	0.12	0.83
12	Crimson Clover	84.0	0.5	4.1	3.0	1.4	7.0	0.47	0.12	0.39
29	Alfalfa	75.0	0.9	6.5	4.5	2.2	10.9	0.72	0.14	0.70
11	Cow Pea	82.5	0.7	3.8	3.1	1.7	8.2	0.50	0.14	0.46
8	Canada Field Pea	81.7	0.6	4.8	2.4	1.6	8.9	0.38	0.17	0.46
8	Soy Bean	79.8	0.8	5.3	3.0	2.0	9.1	0.48	0.15	0.49
1	Velvet Bean	82.2	0.7	5.1	3.5	1.9	6.6	0.55	0.14	0.57
1	Sand Vetch	88.1	0.5	2.6	3.5	1.5	3.8	0.56	0.15	0.54
2	Dwarf Essex Rape	87.9	0.5	1.2	2.4	1.6	6.4	0.37	0.13	0.47
	SILAGE.									
22	Corn (Maize) Silage	79.3	0.7	5.8	1.5	1.3	10.9	0.24	0..2	0.33
6	Sorghum Silage	75.8	0.8	6.3	0.8	1.0	15.8	0.13	0.15	0.19
1	Red Clover Silage	72.6	0.9	8.6	3.8	2.7	11.4	0.61	....	....
4	Brewers' Grains Silage	70.3	2.1	4.5	6.3	1.2	15.6	1.01	....	....
1	Rye Silage	80.8	0.3	5.8	2.4	1.6	9.1	0.38	....	....

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Number of Analyses.		POUNDS PER HUNDRED.								
		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen—Free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
	HAY AND DRIED COARSE FODDER.									
11	Corn Fodder, Field-Cured	25.0	1.7	20.8	5.6	4.9	42.6	0.68	0.36	1.06
16	Cornstalks, Dried	14.7	1.2	27.8	5.1	5.5	46.2	0.82	0.28	0.95
2	Cornstalks, Field-Cured	37.7	1.5	18.9	3.8	3.4	34.7	0.61	0.33	0.83
	Hays from Grasses Named.									
3	Orchard Grass	6.9	1.8	32.3	5.7	5.2	48.1	0.91	0.28	1.64
15	Timothy	11.2	1.9	28.5	6.0	4.2	48.2	0.96	0.36	1.26
8	Hungarian Grass	7.4	1.8	28.0	7.3	6.1	49.4	1.16	0.35	1.29
1	Short Sedge	8.5	2.4	21.8	7.3	10.6	49.9	1.16	0.14	1.18
2	Creek Sedge, Field-Cured	41.8	1.1	16.2	2.0	6.6	32.3	0.33	0.08	0.58
1	Herd Grass	7.5	1.5	26.6	6.3	4.8	53.3	1.00	0.35	1.57
3	Salt Marsh Hay	8.1	2.0	25.8	4.5	6.1	53.5	0.78	0.09	0.82
4	*Black Grass*	9.3	2.5	25.7	6.7	6.9	48.9	1.07	......	......
1	Marsh Rosemary	7.8	2.0	25.1	5.3	5.8	54.0	0.84	0.06	0.27
2	Bog Hay	8.1	2.2	25.1	7.7	8.3	48.6	1.23	0.18	0.73
	Hays from Legumes Named.									
12	Red Clover	8.2	2.8	28.3	12.3	6.6	42.3	1.97	0.40	1.75
1	Alsike Clover	7.5	1.6	29.5	11.4	6.4	43.6	1.83	0.39	2.15
1	White Clover	7.1	2.1	27.3	14.1	9.0	40.4	2.25	0.25	1.06
2	Crimson Clover	8.0	1.7	32.0	15.6	8.4	34.3	2.49	0.66	2.28
5	Alfalfa	9.5	2.6	29.2	15.6	7.5	35.6	2.51	0.48	2.47
3	Cow Pea	12.5	2.1	20.0	16.0	8.4	41.0	2.56	0.58	1.83
1	Oats and Peas Hay	6.6	2.6	30.7	8.0	6.5	45.6	1.28	0.63	1.46
1	Oats and Peas Straw	9.2	2.3	32.8	4.1	6.9	44.7	0.66	0.38	3.20
15	Wheat Straw	7.5	1.6	37.9	2.7	3.7	46.6	0.43	0.13	0.74
6	Rye Straw	6.6	1.3	38.2	3.1	3.3	47.5	0.50	0.29	0.79
7	Oat Straw	8.1	2.1	36.3	4.0	4.8	44.7	0.65	0.22	1.22
1	Buckwheat Straw	9.0	0.7	37.2	7.8	6.5	38.8	1.24	0.13	1.14
1	Sorghum Leaves	10.4	2.0	23.7	9.6	5.4	48.9	1.54	0.52	1.12
1	Sweet Potato Vines, Yellow	13.1	1.7	11.9	15.4	11.8	46.1	2.46	0.60	1.69
1	Sweet Potato Vines, Red	17.2	1.2	14.8	10.6	8.9	47.3	1.69	0.44	1.44
	ROOTS, TUBERS, AND VEGETABLES.									
41	Potatoes	79.1	0.1	0.4	2.1	0.9	17.4	0.33	0.12	0.44
15	Sweet Potatoes	72.6	0.8	0.7	1.0	1.4	24.0	0.16	0.10	0.49
4	*Sugar Beets*	*82.0*	*0.1*	*1.1*	*1.6*	*1.2*	*14.0*	*0.26*	*0.12*	*0.48*
1	Mangelwurzels	91.8	0.1	0.7	1.2	0.9	5.3	0.19	0.06	0.46
12	Tomatoes	94.0	0.4	0.5	0.8	0.5	3.8	0.18	0.07	0.25
1	Apples	84.8	0.8	1.2	0.6	0.3	12.8	0.10	0.02	0.14

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Number of Analyses.		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen—Free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
		POUNDS PER HUNDRED.								
	GRAINS AND OTHER SEEDS									
15	Corn (Maize) Kernel	15.4	4.1	1.5	9.1	1.3	68.6	1.48	0.61	0.36
6	Sorghum Seed	12.3	3.6	1.8	8.6	1.8	71.9	1.38	....	....
20	Oats	11.4	4.8	9.9	11.8	3.1	59.5	1.81	0.77	0.57
6	Rye	12.0	1.7	1.7	10.2	1.8	72.6	1.62	0.81	0.52
21	Wheat	12.7	1.7	1.9	10.8	1.9	71.0	1.73	0.96	0.85
1	Buckwheat	10.8	2.5	8.7	10.1	2.3	65.6	1.62	0.78	0.59
1	Soy Bean	9.6	19.0	5.0	35.4	4.8	26.2	5.67	....	....
2	Cow Pea	10.9	1.5	8.4	19.5	3.3	61.4	3.12	1.01	1.20
1	Blackeyed Pea	12.2	1.6	4.1	21.6	3.3	57.2	3.46	....	....
1	Hungarian Grass Seed	9.5	4.7	7.7	9.9	5.0	63.2	1.59	0.47	0.38
1	Broom-corn Seed	8.9	2.6	....	10.7	4.5	*73.3	1.71	0.72	0.52
1	Rice	12.0	0.8	0.1	7.4	0.2	80.0	1.18	....	....
1	Oats and Peas	9.9	3.8	10.9	16.7	4.7	54.0	2.68	1.02	0.92
	MILL PRODUCTS.									
41	Corn (Maize) Meal	12.9	4.0	1.8	9.1	1.5	70.7	1.47	0.62	0.38
13	Cob Meal	12.5	3.4	5.9	7.6	1.4	69.2	1.22	0.55	0.46
4	Ground Oats	10.8	5.1	9.8	11.2	3.8	59.8	1.79	0.76	0.50
38	Ground Corn and Oats	11.9	4.5	4.0	9.7	2.2	67.7	1.55	0.71	0.44
6	Wheat Flour	12.4	1.2	....	12.0	0.4	74.0	1.92	....	....
5	Buckwheat Flour	14.1	0.8	....	4.8	0.7	79.6	0.77	0.52	0.16
1	Rice Meal	8.5	14.1	8.0	14.4	7.4	47.6	2.30	....	....
2	Pea Meal	10.8	2.2	....	27.4	2.5	*57.1	4.89	0.91	0.99
1	Bean Meal	10.9	1.5	8.8	23.2	5.7	54.9	3.72	0.94	1.45
7	Flaxseed Meal	8.0	35.6	4.9	24.5	4.0	23.0	3.92	1.80	0.98
	BY-PRODUCTS AND WASTE MATERIALS.									
4	Corn (Maize) Cob	31.5	0.3	24.0	1.5	1.0	41.7	0.24	0.07	0.29
29	Hominy Chop, or Meal	9.5	8.8	3.5	10.8	2.8	64.6	1.72	1.48	0.75
15	Chicago Gluten Meal	9.8	4.6	1.9	35.9	0.9	46.9	5.74	0.34	0.06
1	Cream Gluten Meal	7.4	15.6	1.5	41.8	1.6	32.1	6.68	0.31	0.06
3	Hammond Gluten Meal	8.2	11.1	0.9	28.4	1.0	50.4	4.54	0.50	0.08
2	King Gluten Meal	8.8	18.5	1.4	37.2	1.4	33.2	5.95	0.66	0.06
11	† Buffalo Gluten Feed	8.2	12.8	6.6	22.0	0.9	49.5	3.52	0.39	0.06
19	Buffalo Gluten Feed	8.7	3.5	6.9	26.7	3.0	51.2	4.27	....	....
2	Iowa Golden Gluten Feed	8.8	11.6	8.1	29.4	1.0	46.6	4.70	0.43	0.08
2	† Rockford Diamond Gluten Feed	9.0	4.2	8.0	22.9	1.0	54.9	3.66	....	....
4	Rockford Diamond Gluten Feed	....	3.8	....	27.8	....	....	4.87	....	....
1	Atlas Gluten Feed	7.5	9.8	10.6	20.8	1.3	50.0	3.31	0.60	0.23

* Includes fiber. † Samples prior to 1897.

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Number of Analyses.		POUNDS PER HUNDRED.								
		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen—Free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
	BY-PRODUCTS AND WASTE MATERIALS—(Con).									
4	Davenport Gluten Feed	7.8	4.4	7.5	24.1	1.2	55.0	3.86	....	....
1	Waukegan Gluten Feed	....	4.3	....	26.4	....	....	4.22	....	....
1	Marshalltown Gluten Feed	....	3.4	....	29.2	....	....	4.67	....	....
3	Grano Gluten Feed	6.0	14.2	11.4	31.0	2.7	34.7	4.96	0.66	0.20
10	Cerealine Feed	9.8	7.1	5.6	9.8	2.6	65.1	1.57	1.27	0.67
2	Corn Germ Meal	7.2	10.8	7.8	11.4	1.6	61.2	1.82	0.39	0.21
3	Corn Oil Meal	9.0	13.5	6.7	24.8	2.4	43.6	3.97	1.40	0.18
4	Germ Oil Meal	....	9.7	....	16.3	....	....	2.61	....	....
1	Corn Sprouts	8.3	2.3	5.8	26.0	5.6	52.0	4.16	1.54	1.84
13	Corn Bran, or Hulls	8.4	5.8	11.8	9.7	1.3	63.0	1.55	0.62	0.40
5	Fancy Corn Bran	....	3.4	12.0	13.4	....	....	2.14	....	....
1	Maizeline	....	9.0	6.3	10.4	....	....	1.66	....	....
4	Starch Feed, Wet	68.8	3.0	2.9	5.0	0.4	19.9	0.80	0.05	0.02
2	Starch Feed, Dried	9.1	8.8	6.7	14.6	0.9	64.0	2.34	....	....
6	Vim Oat Feed	....	2.2	28.1	5.6	....	....	0.90	....	....
3	Royal Oat Feed	7.7	3.4	22.7	7.3	....	....	1.17	....	....
4	Oat Chop	6.8	8.1	21.1	8.8	5.9	53.8	1.84	0.66	0.69
6	Oat Hulls	7.3	1.1	31.6	2.9	6.7	50.4	0.46	0.24	0.52
1	Hulled Oats	....	7.6	....	16.2	....	....	2.59	....	....
1	De Fi Corn and Oat Feed	....	3.1	14.9	8.7	....	....	1.39	....	....
1	Durham Corn and Oat Feed	....	2.8	13.1	7.5	....	....	1.20	....	....
12	Victor Corn and Oat Feed	....	4.1	10.8	8.7	....	....	1.39	....	....
2	Corn, Oat and Barley Feed	....	4.6	11.5	11.4	....	....	1.82	....	....
9	Quaker Dairy Feed	6.8	3.8	17.6	13.0	5.4	53.9	2.08	....	....
9	H. O. Dairy Feed	8.3	4.2	12.3	18.5	3.6	53.1	2.96	0.84	0.60
9	H. O. Horse Feed	9.6	3.9	9.8	12.6	2.6	61.5	2.02	....	....
5	Friends' Dairy Feed	4.9	3.5	21.5	8.0	5.7	56.4	1.28	0.63	0.65
10	Chester Stock Food	....	3.4	11.1	7.4	....	....	1.18	....	....
28	Malt Sprouts	9.4	2.5	10.0	25.5	7.9	44.7	4.01	1.58	1.87
13	Brewers' Grains, Wet	74.1	2.1	3.7	6.4	1.0	12.7	1.02	0.26	0.08
42	Brewers' Grains, Dried	8.9	7.0	13.2	23.9	3.7	43.3	3.82	1.01	0.09
1	Brewers' Swill	94.3	0.8	0.7	1.9	0.8	2.0	0.30	....	....
2	Distillery Grains, Dried	7.2	16.9	13.7	26.2	1.1	35.9	4.19	0.87	0.12
73	Cottonseed Meal	7.6	10.3	5.2	44.8	6.5	25.6	7.17	3.15	1.79
9	Cotton-seed Meal, Undecorticated	8.8	7.4	18.5	25.3	4.9	35.1	4.04	1.85	1.48
1	Cotton-seed Feed	9.7	3.8	35.7	10.7	3.7	36.9	1.72	0.62	1.21

AVERAGE ANALYSES OF FODDERS AND FEEDS.

Number of Analyses.		POUNDS PER HUNDRED.								
		Water.	Ether Extract.	Fiber.	Protein.	Ash.	Nitrogen—Free Extract.	Nitrogen.	Phosphoric Acid.	Potash.
	BY-PRODUCTS AND WASTE MATERIALS—(Con).									
116	Linseed Meal, Old Process	9.7	7.3	7.8	33.8	5.5	36.4	5.41	1.94	1.34
6	Linseed Meal, New Process	9.3	8.2	8.1	35.3	5.7	38.4	5.65	2.16	1.49
2	Palm-nut Meal	8.5	12.6	22.8	14.8	3.6	37.7	2.37	....	....
1	Pea Feed	10.1	1.2	....	14.9	3.0	*70.8	2.39	0.72	0.72
1	Peanut Meal and Hulls	10.9	2.4	62 9	7.0	2.1	14.7	1.18	0.15	0.62
1	Cocoa Shells	2.7	16.5	9.9	15.5	10.7	44.7	2.48	1.14	2.39
1	Sugar Beet Feed	....	0.8	19.2	8.2	....	....	1.31	....	....
1	Clover Meal	....	3.3	29.2	5.8	....	....	0.93	....	....
3	Rice, Bran or Feed	9.0	9.3	18.0	11.5	9.2	48.0	1.84	....	....
1	Rice Polish	9.5	11.2	3.8	14.3	6.8	55.4	2.29	3.29	1.19
3	Buckwheat Bran	12.9	5.9	13.3	22.2	4.3	41.4	3.56	1.79	1.14
8	Buckwheat Middlings	13.7	5.7	2.9	21.0	3.9	52.8	3.36	1.78	1.03
9	Rye Bran	11.7	2.8	3.5	13.9	3.3	64.8	2.25	1.54	0.95
4	Rye Feed	12.1	1.8	1.4	9.3	1.7	73.7	1.49	0.77	0.47
1	Rye Middlings	12.2	2.8	1.3	13.3	1.7	68.7	2.13	0.56	0.49
1	Barley Meal	....	4.6	12.8	13.8	....	....	2.21	....	....
62	Wheat Bran	11.3	4.1	7.9	15.7	6.0	55.0	2.51	2.92	1.57
23	Wheat Middlings, White	11.4	3.6	4.2	15.4	2.7	62.7	2.46	1.35	0.76
6	Wheat Middlings, Brown	10.7	4.5	4.5	16.9	3.8	59.6	2.71	1.87	0.94
2	Wheat Shorts	11.2	3.3	2.3	15.5	2.2	65.0	2.48	1.18	0.56
2	Wheat Chaff	11.1	1.4	29.2	4.3	6.5	47.5	0.69	0.95	0.56
4	Ship Stuff	12 0	3.6	4.6	16.1	4.3	59.4	2.58	2.04	0.51
3	Buckeye Wheat Feed	....	4.5	5.9	17.1	....	....	2.74	....	....
4	Wheat Feeds	....	4.5	7.2	17.3	....	....	2.77	....	....
2	Sucrene Dairy Feed	10.2	5.3	9.0	19.4	....	....	3.10	....	....
1	Nutrisotône	6.1	6.5	6.1	21.3	19.7	38.3	3.41	3.19	3.06
1	Paine's Stock Food	11.3	10.3	10.1	11.3	10.1	46.9	1.80	1.98	0.82
1	Banner Stock Food	....	8.4	....	22.8	....	....	3.65	....	....
1	Baum's Horse and Stock Feed	....	9.2	18.3	24.8	....	....	3.97	....	....
4	Blatchford's Calf Meal	8.7	5.3	4.7	25.3	5.7	50.3	4.05	....	....
2	American Calf Meal	....	8.0	2.3	17.4	....	....	2.78	....	....
2	American Poultry Food	....	6.6	4.7	18.0	....	....	2 08	....	....
7	H. O. Poultry Feed	....	5.5	4.7	17.4	....	....	2.78	....	....
2	H O. Scratching Feed	....	4.4	....	12.3	....	....	1.97	....	....
3	Animal Meal	....	8.8	....	42.1	....	....	6.74	....	....
3	Beef Meal	....	12.9	....	58.6	....	....	9.41	....	....

* Includes fiber.

MARKET PRICES OF COMMERCIAL FEEDS.

The gathering of statistics concerning the average market prices of commercial feeds used in the State was begun in 1891. It has been continued since, though with some changes as to method. Up to January 1st, 1900, the records represented the average price per ton for the six months preceding January 1st. This year a change has been made, which it is believed will more accurately represent the actual prices paid for feeds during the year, since they are the average prices of feeds obtained direct from dealers, which were sampled for analysis under the law passed in 1900 and now in force. Besides, the average now represents a larger number of samples distributed more generally over the State. The results of the inspection showed a larger number of specific brands than have been included in previous years. Hence a comparative study of composition and prices cannot be made in all cases this year. Such comparisons as can be made, show that, with one exception, there has been an increase in the average price of all the feeds, ranging from 28 cents per ton for rye bran to $5.14 per ton for linseed meal. The average increase for all is 12 per cent. It is also shown that the increase affects in practically the same degree the two general classes of feeds, namely, the protein and the carbohydrate. The very considerable increase in price of corn meal, namely, 27 per cent., is suggestive, since it is one of the feeds which has been used more generally than any other by the farmer, and suggests the importance of a careful study of the exchange of home-grown products for those richer in protein.

KIND OF FEED.	AVERAGE FOR THE SIX MONTHS PRECEDING JANUARY 1.					Average from November 1, 1900, to May 15, 1901.
	1895–96.	1896–97.	1897–98.	1898–99.	1899–00.	
Cottonseed Meal	$21 86	$22 40	$23 00	$20 22	$25 33	$28 70
Linseed Meal, old process	22 65	22 97	24 82	25 30	28 94	34 08
Chicago Gluten Meal	18 66	14 83	16 83	19 83	22 42	26 08
Marshalltown Gluten Feed	......	......	......	......	......	22 00
Rockford Diamond Gluten Feed	......	......	......	15 75	17 00	21 10
Buffalo Gluten Feed	16 83	12 00	15 22	15 92	18 41	21 87
Waukegan Gluten Feed	......	......	......	......	......	21 50
Davenport Gluten Feed	......	......	......	......	......	20 70
Malt Sprouts	15 18	10 90	12 C8	14 58	15 89	17 50
Dried Brewers Grains	15 83	12 88	15 13	14 92	17 67	19 06
Sucrene Dairy Feed	......	......	......	......	......	21 00
Germ Oil Meal	......	......	......	......	......	22 75
Wheat Bran	16 45	12 81	14 10	15 43	17 48	21 13
Wheat Middlings	19 67	14 98	15 85	17 87	19 15	22 63
Ship Stuff	16 88	12 75	14 89	16 67	18 22	18 50
Wheat Feed (Mill Feed)	......	......	......	......	......	19 75
Buckeye Wheat Feed	......	......	......	......	......	20 88
H. O. Dairy Feed	......	......	......	......	......	22 70
H. O. Horse Feed	......	......	......	......	......	21 88
Quaker Dairy Feed	......	......	......	......	......	13 86
Victor Corn and Oat Feed	......	......	......	......	......	18 55
Corn, Oat and Barley Feed	......	......	......	......	......	20 00
Corn Bran, or Sugar Feed	......	......	......	......	......	17 10
Barley Meal	......	......	......	......	......	22 00
Hominy Meal	16 75	12 75	13 94	15 94	17 00	19 05
Rice Feed	......	......	......	......	......	18 50
Cerealine Feed	......	......	......	......	......	19 75
Corn Meal	18 84	14 83	15 02	16 62	17 25	22 00
Ground Oats	20 92	18 76	22 58	24 31	23 75	25 00
Corn and Oats (Provender)	19 49	14 29	16 69	19 79	19 81	20 90
Corn-Ear Meal	15 95	12 60	13 67	15 92	14 38	15 41
Rye Bran	17 67	11 13	12 44	14 69	17 22	17 50
Rye Middlings	18 88	14 40	15 50	16 97	18 60	18 00
Friends' Dairy Feed	......	......	......	......	......	16 13
Chester Stock Feed	......	......	......	......	......	18 75
Oat Feed, or Chop	......	......	......	13 25	14 8[illegible]	15 75

NITROGEN INVESTIGATIONS.

THE AVAILABILITY OF ORGANIC NITROGEN IN RAW MATERIALS.

BY JOHN PHILLIPS STREET.

In the report of this Station for 1898* there was suggested a method for the determination of the relative availability of the organic nitrogen in raw materials. The figures there published showed that with the materials examined, twenty in number, the method gave very satisfactory results. It was not claimed that the percentages obtained showed *absolute* availability, but it was asserted that by this method it was possible to determine the *relative* availability to the plant of the organic nitrogen obtained in the well-known ammoniates. This assertion has been confirmed in some cases by a comparison with actual vegetation tests, and in others, as, for instance, leather and the various bones, by the knowledge we possess as to what they will do in the field.

It was thought that it might be valuable likewise to ascertain the variations that occur in the availability of materials of the same class, and accordingly all of the samples of raw materials received at this Station during the past three years have been submitted to this test. In addition to these samples, the analyses published in 1898, certain samples received from referees of the Association of Official Agricultural Chemists, and various samples of the different kinds of bone from our own stock have been included. The tests reported on the following pages include the examination of 122 samples representing thirty-one different kinds of ammoniates.

For convenience, the method used is again reported :

Method.—Weigh an amount of the material equivalent to 0.075 grams of nitrogen into a 500 cc. Erlenmeyer flask ; add 100 cc. of neutral 1.6 per cent. permanganate of potash solution, and digest on a steam bath for thirty minutes, shaking occasionally to moisten any particles adhering to the sides of the flask. Filter and wash three or four times, using from 125 to 150 cc. of water. Determine the total nitrogen in the undigested residue by the ordinary Kjeldahl method.

* Report N J. Exp. Station, 1898, page 98.

Note.—The original method has since been modified by the use of a 400 cc. beaker instead of a flask, the same to be immersed in boiling water during the digestion and covered with a cover glass. This modification facilitates manipulation and secures more uniformity of temperature during the digestion.

Inasmuch as this method has no official standing, in the following tables the name of the manufacturer of the material is in every case omitted :

	Per Cent. of Organic Nitrogen.	Percentage Availability.		Per Cent. of Organic Nitrogen.	Percentage Availability.
Dried Blood	12.41	95.6	Dried Blood	13.41	89.8
" "	13.20	95.2	" "	11.06	87.4
" "	13.11	95.2	Average	12.62	93.0
" "	14.01	95.0	Ground Horn	14.65	95.9
" "	12.85	94.6	Concentrated Tankage	11.13	93.7
" "	13.60	94.4	Ammonite	13.00	93.6
" "	13.73	94.8	"	12.83	95.4
" "	14.04	94.0	Average	12.92	94.6
" "	11.39	92.7	Cracklings	13.22	93.5
" "	13.41	92.2	Hoof Meal	14.47	92.2
" "	11.63	91.9	" "	14.04	89.7
" "	11.89	91.8	Average	14.26	91.0
" "	13.10	91.0			

The fifteen samples of dried blood examined range in availability from 87.4 to 95.6, with an average of 93.0 per cent. All of the higher-grade bloods, with one exception, show a somewhat higher degree of availability than those of lower grade (containing less than 12 per cent. of nitrogen). The average availability of the former is 93.7 and of the latter 91.0 per cent., which is due chiefly to the presence of considerable phosphoric acid in the latter, one sample showing as much as 3.44 per cent., thus indicating the admixture of some foreign matter, probably bone. These figures show that the dried blood on the market for the past three years has been of excellent quality and contains nitrogen in a very available form.

The other materials reported in the above table, ground horn, concentrated tankage, ammonite, cracklings and hoof meal, all show a

high degree of availability. As stated in a previous report, the sample of ground horn is probably better than the average, as it was an old sample and in a very pulverulent condition. The samples of hoof meal were submitted to a vegetation test at this station, and showed a relation to dried blood almost identical with the figures in the table. All of these materials furnish organic nitrogen in a very available form.

	Per Cent. of Organic Nitrogen.	Percentage Availability.		Per Cent. of Organic Nitrogen.	Percentage Availability.
Dried Fish	10.28	92.9	Dried Fish	6.50	82.9
" "	8.34	90.7	" "	8.26	82.6
" "	8.56	90.7	" "	8.34	82.3
" "	8.78	90.2	" "	7.75	82.2
" "	9.38	90.1	" "	8.23	82.1
" "	7.97	90.0	" "	5.07	81.9
" "	8.22	89.9	" "	8.44	81.4
" "	7.58	88.7	" "	7.49	79.6
" "	8.80	88.5	" "	8.12	79.3
" "	8.39	88.2	" "	6.82	78.4
" "	8.39	88.2	" "	5.07	74.7
" "	9.53	88.0	" "	6.47	74.4
" "	8.69	87.6	" "	6.76	70.8
" "	7.89	87.1	" "	6.86	70.1
" "	6.82	86.7	" "	5.19	69.3
" "	8.28	86.5	" "	6.20	66.9
" "	8.83	86.3	" "	6.96	65.8
" "	9.48	86.1	" "	7.04	65.8
" "	4.57	86.0	" "	4.68	61.4
" "	8.87	85.0	" "	7.07	62.9
" "	7.80	84.7	" "	5.14	56.1
" "	7.61	83.5	Average	7.54	81.1

The forty-three samples of dried fish reported in the above table show wide variations in availability, ranging from 56.1 to 92.9 per cent. If we make a somewhat arbitrary division of the samples, classing those containing more than 7 per cent. of nitrogen as high-grade, and those below that figure as low-grade, we find that, with a

very few exceptions, these differences become much smaller, the average availability for the high-grade samples being 86.4 per cent., and that for the low-grade 72.3 per cent. The differences in the nitrogen availability of different samples of fish arise from the varying amounts of flesh, bone and oil which they contain, any excess of flesh showing itself in an increased nitrogen content, and any excess of bone or oil causing a lower percentage of nitrogen. These facts, together with the figures of the above table, show that, with a very few exceptions, in this class of goods the percentage of nitrogen contained is a fairly reliable guide as to the availability of the nitrogen. A wet, oily fish containing a large proportion of bone naturally would be less available to the plant than one whose chief constituent was fine dried flesh. The proportion of salt contained also has considerable influence on the usefulness of the fish to the growing plant.

	Per Cent. of Organic Nitrogen.	Percentage Availability.
Tankage	8.63	93.2
"	7.48	92.3
"	6.90	91.5
"	5.00	91.2
"	7.67	89.5
"	7.20	89.2
"	6.53	88.4
"	5.88	87.1
"	6.42	85.4
"	5.69	84.0
"	6.65	81.8
"	5.67	79.8
"	5.89	79.7
"	5.34	79.7
"	5.16	65.0
Average	6.41	85.2
Dissolved Tankage	5.02	65.9
" "	2.93	63.1
Average	3.98	64.5
Degelatinized Bone	0.54	87.3

	Per Cent. of Organic Nitrogen.	Percentage Availability.
Dissolved Bone	2.[illegible]0	83.1
" "	1.95	62.7
Steamed Bone	2.78	87.0
" "	2.25	84.8
" "	2.20	81.9
Average	2.41	84.6
Button Bone	3.14	86.7
" "	3.33	84.0
Average	3.24	85.4
Bone Sawings	3.80	79.7
" "	3.85	77.6
" "	3.93	76.0
Average	3.86	77.8
Soft Ground Bone	2.87	71.6
Raw Ground Bone	3.93	70.0
" " "	3.40	66.9
" " "	4.12	66.8
" " "	4.05	66.2
Average	3.88	67.4

The fifteen samples of tankage show a variation in availability ranging from 93.2 to 65.0 per cent., with an average of 85.2 per cent. Like fish, tankage is a very variable material, as these figures show, but unlike fish, the percentage of nitrogen contained is of little value as indicating the nitrogen availability. The possibility of the manufacturer making his tankage a vehicle for the disposal of the crudest offal of the slaughter house, as is frequently done, makes it necessary for the consumer to use great care in its purchase. The percentage of phosphoric acid present (in the above samples, ranging from 8.02 to 18.06 per cent.), is a partial guide as to its source, but too much dependence cannot be placed on this, for while a high content of phosphoric acid is almost certain evidence that bone is an important constituent, a low content of phosphoric acid does not necessarily indicate that high-grade materials have been used in making up the tankage. The availability of the nitrogen of the two samples of dissolved tankage reported is somewhat lower than would he expected from experience with analagous materials.

In the above table are also grouped sixteen samples of bone representing seven classes of that product. The degelatinized bone, made by a patent process, shows a high degree of availability. This particular sample showed more than half of its total nitrogen in the form of ammonia salts, and its organic nitrogen appears also to be very available. The two samples of dissolved bone show a wide divergence. The sample called "soft ground bone" in appearance strongly resembles dissolved bone, and its availability shows it to belong to that class of materials. Of the remaining classes of bone shown in the table, steamed bone and button bone show the highest availability, while bone sawings and raw bone are considerably lower. The process of steaming removes the greater part of the fatty matter, and this probably accounts for its higher availability than the more crude forms. Likewise in button bone, the bone used for this purpose is almost completely freed of fat and consequently shows a high availability. Raw bone, containing as it usually does, considerable quantities of fatty matter, shows the lowest availability of any of the forms of bone examined.

	Per Cent. of Organic Nitrogen.	Percentage Availability.		Per Cent. of Organic Nitrogen.	Percentage Availability.
Castor Pomace	6.12	90.0	Wool Waste	2.47	54.9
Peanut Pulp	8.52	89.3	Average	2.46	71.3
Cottonseed Meal	6.81	82.6	King Crab	8.78	72.5
" "	7.33	79.6	" "	9.12	62.5
" "	6.74	78.6	Hair Manure	5.76	64.6
Average	6.79	80.3	Garbage Fertilizer	2.95	59.2
Linseed Meal	5.94	77.7	" "	3.20	44.1
Horse Meat	4.29	70.4	" "	2.99	42.7
Pigeon Manure	6.67	88.8	Average	3.05	48.7
Wool Waste	2.58	77.6	Burned Garbage	1.95	51.5
" "	2.34	75.6	Snuff Sand	1.03	48.3
" "	2.52	75.1	Steamed Leather	6.87	39.5
" "	2.51	75.0	Treated Leather	7.22	33.4
" "	2.31	69.8	Raw Leather	7.56	25.5

The above table shows the availability of the nitrogen in twenty-five samples, representing fifteen kinds of material. The figures obtained indicate that castor pomace, peanut pulp, pigeon manure, cottonseed meal and linseed meal should be classed with the high-grade ammoniates. The horse meal ranks with an inferior tankage, and the king crab with inferior fish, the availability of the second sample, however, being even several per cent. lower than the poorest fish reported. The samples of wool waste, with one exception, are very uniform both in composition and availability and occupy a place somewhat below fish, and an intermediate position between the good and the poor materials. The remaining materials are of known inferiority, and the availabilities they show under the action of permanganate indicate that the method is successful in differentiating the good and the bad materials. Three other samples of hair manure, besides the one reported in the table, were examined, but are excluded because of the uncertainty as to their origin. One sample contained as much as 10.48 per cent. of nitrogen, and this high nitrogen content together with the high availability shown (81.0, 85.8 and 93.2 per cent.) seemed to indicate that they did not fairly represent the material known as crude hair. Much treated

hair has appeared for sale in recent years, particularly in southern markets, and these samples may belong to that class, thus accounting for the high availability shown. The snuff sands represents the sweepings from a snuff factory, and the low availability, 48.3 per cent., indicates that it is much inferior to the high-grade ammoniates. The samples of garbage and those of leather, both in the treated and untreated form,* occupy the lowest position of any of the samples examined.

The following table gives a summary of the average results obtained in the thirty-one classes of materials examined :

Average Availability of Organic Nitrogen.

Number of Analyses.		Percentage Availability.	Number of Analyses.		Percentage Availability.
1	Horn Meal	95.9	3	Cotton-seed Meal	80.3
2	Ammonite	94.5	3	Bone Sawings	77.8
1	Concentrated Tankage	93.7	1	Linseed Meal	77.7
1	Cracklings	93.5	1	Soft Ground Bone	71.6
15	Dried Blood	93.0	6	Wool Waste	71.3
2	Hoof Meal	91.0	1	Horse Meat	70.4
1	Castor Pomace	90.0	4	Raw Bone	67.4
1	Peanut Pulp	89.3	2	Dissolved Tankage	64.5
1	Pigeon Manure	88.3	2	King Crab	62.5
1	Degelatinized Bone	87.8	1	Hair Manure	54.6
2	Button Bone	85.4	1	Burned Garbage	51.5
15	Tankage	85.2	3	Garbage Fertilizer	48.7
3	Steamed Bone	84.6	1	Snuff Sand	48.3
21	Dissolved Bone	83.1 62.7	1	Steamed Leather	39.5
			1	Treated Leather	33.4
43	Dried Fish	81.1	1	Raw Leather	25.5

INVESTIGATIONS RELATIVE TO THE USE OF NITROGENOUS MATERIALS.

BY EDWARD B. VOORHEES.

Losses from Farmyard Manures When Allowed to Leach.

These experiments, while primarily planned to obtain data concerning the relative availability of nitrogen in farmyard manure of various kinds, and of the commercial nitrogenous products, admitted a study of the losses, both in fertility elements direct, in availability that may occur in the improper handling of cow manure made upon the farm.

That phase of the experiments which enabled a study of the losses that may occur through exposure, included four lots of manure, each lot including the solid excrement only, and the solid and liquid excrement combined. These were exposed for different periods and at different seasons of the year, thus making the average of the four lots fairly representative of the average period during which manure is most likely to be exposed, as well as representing manures made under different conditions of feeding, summer and winter. The manure was carefully collected, and 100 pounds of each lot placed in a galvanized iron box, 8 inches deep, with a perforated bottom, covered with wire gauze to prevent mechanical losses, and then exposed in the open air, as follows :

First lot, February 4th to June 5th, 1898.	A period of 131 days.
Second lot, February 3d to April 13th, 1899.	" " 70 "
Third lot, February 7th to April 20th, 1900.	" " 76 "
Fourth lot, August 9th to September 27th, 1900.	" " 50 "

In the next place, in order to eliminate unequal factors as far as possible, the manures used in the experiment were not mixed with litter or other substances, and hence the results may not be strictly comparable with those obtained under the average conditions of handling, where litter and absorbents are used; nevertheless, the losses that occur and the availability of the material of different kinds would undoubtedly be relatively the same. For example, if it is shown that 40 per cent. of the nitrogen contained in solid manure is lost by exposure for a certain period, and 50 per cent. of the nitrogen in the solid and liquid manure is lost under the same conditions as

to time and season, the relations would be the same, even though the two kinds were admixed with other materials; or, in other words, the presence of an equal amount of litter would have practically the same effect upon one lot as upon another. Furthermore, if it were shown that the nitrogen in the fresh solid manure showed an availability for a crop or season of 15 per cent., and the availability of the nitrogen in the fresh solid and liquid manure was 40 per cent., the relative availability would be likely to be the same, even though the materials were admixed with other substances. It seemed best to study the two products, solid, and the solid and liquid combined, which would be relatively the same upon any farm, provided the feeding was the same, rather than a mixture of other materials, which would vary with the different producers.

Chemical analyses were made, both at the time the manures were placed in the boxes, and again at the end of the period. The losses calculated on the basis of the amount of constituents contained in 100 pounds of the dry matter of the original manure, are shown in Table I.

TABLE I.

Losses Sustained by Manures on Exposure.

Solid Manure.

Lot.	Period.		Ash.	In 100 pounds of dry matter — Organic matter.	Nitrogen.	Phosphoric acid.	Potash.
1.	131 days.	Original..........lbs.....	12.166	87.834	2.286	2.915	1.488
		Loss..................lbs.....	5.085	44.915	1.041	2.211	1.196
		Per cent ....lost...	**41.8**	**51.1**	**46.0**	**72.0**	**80.0**
2.	70 days.	Original..........lbs.....	15.607	84.393	2.094	2.215	1.262
		Loss..................lbs.....	5.369	20.631	0.705	0.591	0.138
		Per cent ....lost...	**34.4**	**24.4**	**34.0**	**27.0**	**10.0**
3.	76 days.	Original..........lbs.....	11.849	88.151	2.128	2.315	1.408
		Loss..................lbs.....	3.700	23.300	0.524	1.242	0.672
		Per cent ....lost..	**31.2**	**26.4**	**25.0**	**54.0**	**48.0**
4.	50 days.	Original..........lbs.....	17.507	82.493	2.383	1.873	0.859
		Loss..................lbs.....	7.114	36.386	1.076	0.798	0.365
		Per cent ....lost...	**40.6**	**44.1**	**45.0**	**42.0**	**42.0**
	Average original..........lbs.....		14.282	85.718	2.223	2.330	1.254
	Average loss..................lbs.....		5.817	31.233	0.837	1.209	0.592
	Average per cent..........lost...		**37.2**	**36.4**	**37.6**	**51.9**	**47.1**

Solid and Liquid Manure Combined.

Lot.	Period.		Ash.	Organic matter.	Nitrogen.	Phosphoric acid.	Potash.
			In 100 pounds of dry matter				
1.	181 days.	Original.........lbs......	12.924	87.076	3.558	2.582	2.331
		Loss...............lbs	3.602	35.398	2.010	1.594	1.684
		Per cent.........lost.....	**27.8**	**40.6**	**57.0**	**62.0**	**72.0**
2.	70 days.	Original.........lbs......	14.127	85.873	2.929	2.019	1.899
		Loss ....lbs	4.151	24.849	1.275	0.333	0.524
		Per cent.........lost.....	**29.4**	**28.9**	**44.0**	**16.0**	**28.0**
3.	76 days.	Original.........lbs......	13.687	86.313	3.576	2.321	1.845
		Loss ....lbs......	4.469	27.541	1.397	1.472	1.034
		Per cent.........lost.....	**32.6**	**31.9**	**39.0**	**63.0**	**56.0**
4.	50 days.	Original.........lbs	21.619	78.381	2.529	1.877	4.425
		Loss ....lbs	14.252	51.248	1.739	1.103	3.181
		Per cent.........lost.....	**65.9**	**65.4**	**69.0**	**59.0**	**72.0**
	Average original............lbs......		15.589	84.411	3.147	2.200	2.625
	Average loss .... lbs		6.616	34.759	1.605	1.126	1.606
	Average per cent..........lost.....		**42.4**	**41.2**	**51.0**	**51.1**	**61.1**

It was possible to include in the study of losses the mineral constituents, phosphoric acid and potash, as well as the nitrogen; the experiment proper, however, did not include a study of their effect upon crop production, since an excess of these was added in all cases, in order to study the one question of the availability of the nitrogen.

In the first place, it is shown that there is a very considerable difference as to the rate of loss, influenced both by the length of time and the season during which it was exposed, as well as the character of the manure. In the case of the solid manure, the loss of nitrogen ranges from 25 per cent. in the third period, to 46 per cent. in the first period; the loss of phosphoric acid ranges from 27 per cent. in the second period, to 72 per cent, in the first period, and the loss of potash ranges from 10 per cent. in the second period, to 80 per cent. in the first period. In the case of the solid and liquid combined, the loss of the nitrogen ranges from 39 per cent. in the third period, to 69 per cent. in the fourth period; the loss of phosphoric acid ranges from 16 per cent. in the second period, to 63 per cent. in the third period, and the loss of potash ranges from 28 per cent. in the second period, to 72 per cent. in both the first and fourth periods. In the case of the nitrogen and potash the greatest loss occurred in the solid and liquid, while in the case of phosphoric acid the loss is practically identical, whether in the solid, or in the solid and liquid manure. Of the ash and organic matter, the greatest loss occurred in the case of the solid and liquid combined.

The average of all the experiments shows a loss in the solid manure of 37.6 pounds from every hundred of nitrogen, 51.9 from every hundred of phosphoric acid, and 47.1 pounds from every hundred of potash. In the solid and liquid combined, there was an average loss of 51.0 pounds of nitrogen from every hundred contained in the original manure, 51.1 pounds from every hundred of phosphoric acid, and 61.1 pounds from every hundred of potash, or nearly one-half of the total contained in the solid manure, and more than one-half of the total contained in the solid and liquid combined.

What the Losses Represent in Plant-Food in Commercial Forms.

It does not follow that manures can be so handled as to prevent all of this loss of constituents before they are applied to the land, particularly in the case of the constituent nitrogen, because changes take place very rapidly. Nevertheless, the greatest losses from both careless and careful handling are liable to fall upon the solid and liquid combined, rather than upon the solid portion, and, therefore, care should be exercised to prevent the conditions which favor such loss. Assuming that the figures here obtained do represent the possible, or even maximum losses, the following calculations are of interest. The solid and liquid manures represented in the experiments contained, on the average:

Nitrogen	0.457 per cent.
Phosphoric acid	0.300 "
Potash	0.348 "

It has been shown by the records kept at the College Farm as to the amount of manure product, that the average production of solid and liquid manure, unmixed with litter, amounted to 70 pounds per day, or an equivalent of 12.78 tons per cow per year; the cows ranging in weight from 850 to 1,500 pounds, an average of about 1,000 pounds. There would be contained, therefore, in the manure made in one year by a well-fed cow, 117 pounds of nitrogen, 77 pounds of phosphoric acid and 89 pounds of potash. These constituents are equivalent in amounts to what is contained in 731 pounds of nitrate of soda (16 per cent.), 550 pounds of acid phosphate (14 per cent.) and 178 pounds of muriate of potash (50 per cent). This amount of manure, if exposed for an average of 82 days between February and October, would lose 60 pounds of nitrogen, 39 of phosphoric acid and 54 of potash, or an equivalent of 380 pounds of nitrate of soda, 277 of acid phosphate and 108 of muriate

of potash. Without regard to the value, there would have been lost these amounts of essential constituents. If the manure had been handled in the best manner, a part of the nitrogen contained might have been lost, because of the tendency to fermentation, resulting in the escape of ammonia, but the mineral constituents could have suffered no loss, without exposure to conditions which permit leaching. That losses of the constituents of manures do constantly occur is abundantly evident to anyone who observes the conditions obtaining on many dairy farms, for in both winter and summer the manures are allowed to lie in the open yard, often in loose heaps, which favor fermentation, and subjected to the leaching from every rain that falls. These conditions must result in great loss, and the probabilities are that the amounts annually lost are as great, if not greater, than is shown by these actual figures.

Value of the Constituents Lost.

It is difficult to affix a value to these constituents, since it is manifestly unfair to apply the same commercial values to the constituents contained in yard manure as are affixed to the constituents in commercial fertilizers, because commercially the conditions are different; yet, it is a fair assumption that if the constituents lost were replaced by those from regular commercial sources, it would cost exactly what commercial relations have fixed for these products. The amounts of the materials indicated as containing constituents equivalent to those lost would cost at the present time, at wholesale, unmixed, $12.50. If they were purchased in the form of New York manure, at prices at which the product is delivered at consumer's depots in the trucking districts, viz., $2 per ton, they would cost $11.50, or but slightly less than if purchased in commercial forms, though at a much greater expense for labor. From either standpoint the constituents possibly lost from the manure of one well-fed cow for one year represents a considerable financial outlay, if the loss is to be made good by purchased supplies. On the basis of the cost of constituents in commercial fertilizers, it is equivalent to 25 cents per hundred for the milk of a 5,000-pound cow, and 23 cents per hundred on the basis of the cost of New York manure. That is, if the fertility of the farm so lost was made good by the purchase of commercial fertilizer, or of New York manure, then the cost of production per hundred of milk would be increased by these amounts, and conversely, if the losses were prevented and the outlay not required, the cost per hundred of milk would be decreased by 25 and 23 cents, respectively.

EXPERIMENTS IN 1900.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH.

The samples were obtained by collecting from a cow, well fed, a considerable amount of the solid manure, and of the solid and liquid manure, or total excrement. The samples were thoroughly mixed, and two pounds taken for analysis, which showed the following composition :

	Fresh Manure	
	A. Solid. Per cent.	B. Solid and Liquid. Per cent.
Water	85.011	85.095
Ash	1.776	2.040
Organic matter	13.213	12.865
Nitrogen (total)	0.319	0.533
" water-soluble	0.051	0.280
" as nitrates	....	....
" as ammonia	....	0.089
" as soluble organic	0.051	0.191
" as insoluble organic	0.268	0.253
Phosphoric acid	0.347	0 346
Potash	0.211	0.275

A study of the analyses shows that 0.051 per cent. of the solid and 0.280 per cent. of the solid and liquid manure was soluble nitrogen ; that is, 16 and 36 per cent., respectively, of the total nitrogen was soluble in water. The content of potash was nearly 68 per cent. greater in the combined solid and liquid manure. That is, the solid and liquid manure shows a higher percentage of the valuable constituents, not only, but a greater solubility of the nitrogen.

THE COMPOSITION OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED.

For the purpose of leaching, 100 pounds of each of these fresh manures were collected and placed in galvanized-iron boxes, eight inches deep, and with a perforated bottom, so as to permit drainage, though covered with a wire gauze above and below, in order to prevent loss of solid matter. The boxes, with their contents, were placed in an exposed place in the open air, and allowed to remain undisturbed from February 2d to April 20th, a total period of

seventy-six days. As the temperature was too low in the months of February and March to cause any fermentation, the losses likely to occur would be due to a carrying away of the soluble constituents by the water from the rains passing through the boxes. On April 2d, the contents of the boxes were weighed, and it was found that the 100 pounds in the case of the solid manure had contracted to 73 pounds, and in the case of the solid and liquid to 68 pounds. Samples were again taken and analyses made as in the case of the fresh products. The results were as follows :

Composition of Manures on Water-Free Basis.

	Solid. Fresh. A. Per cent.	Solid and Liquid. Fresh. B. Per cent.	Solid. Leached. C. Per cent.	Solid and Liquid. Leached. D. Per cent.
Ash	11 849	13.687	11.163	13.570
Organic matter	88.151	86.313	88.837	86 430
Nitrogen (total)	2.128	3.576	2 197	3 204
" water-soluble	0.340	1.879	0.456	1.456
" as nitrates	....	....	....	....
" as ammonia	....	0.597	....	0.617
" as soluble organic	0.340	1.282	0.456	0.839
" as insoluble organic	1.788	1.697	1.741	1.748
Phosphoric acid	2.315	2.321	1.470	1.248
Potash	1.408	2.321	1.008	1.193

Losses Sustained by Leaching.

	74 Pounds of C Contains,	Loss.	71 Pounds of D Contains,	Loss.
Ash	8.149	3.700	9.228	4.459
Organic matter	64.854	23 300	58.772	27.541
Nitrogen (total)	1 604	0.524	2.179	1.397
" water-soluble	0.333	0.007	0 990	0.889
" as nitrates	....	....	....	....
" as ammonia	....	....	0.420	0.177
" as soluble organic	0.333	0 007	0.570	0 712
" as insoluble organic	1.271	0.517	1 189	0 508
Phosphoric acid	1 073	1.242	0.849	1.472
Potash	0.736	0.672	0.811	1.034

These calculations show that the losses were considerable; in sample C (solid manure), 25 per cent. of the nitrogen, 54 per cent. of the phosphoric acid and 48 per cent. of the potash were lost, while in sample D (solid and liquid manure), 39 per cent. of the nitrogen, 63 per cent. of the phosphoric acid and 56 per cent. of the potash were lost. The loss of ash in sample C was 31.2 per cent. compared with a loss of 32.6 per cent. in sample D, while the losses in organic matter were 26.4 per cent. in C, and 31.9 per cent. in D.

The nitrogen, as well as the mineral constituents remaining in the leached residues, consisted, therefore, of the less soluble portions of the manure. The composition of the fresh manure, and of the leached manures, used in the experiment, are shown in the accompanying table:

	Fresh Manures.		Leached Manures.	
	Solid. Per cent.	Solid and Liquid. Per cent.	Solid. Per cent.	Solid and Liquid. Per cent.
Water	84.901	84 368	81.152	80.214
Ash	2.109	2.356	2.104	2.685
Organic matter	12.990	13.276	16.744	17.101
Nitrogen (total)	0.325	0.515	0.414	0.634
" water-soluble	0.066	0.269	0.086	0.288
" as nitrates	......	......	......	......
" as ammonia	......	0.047	......	0.122
" as soluble organic	0.066	0.222	0.086	0.166
" as insoluble organic	0.259	0.246	0.328	0.346
Phosphoric acid	0.272	0.246	0.277	0.247
Potash	0.206	0.301	0.190	0.236

Description of the Experimental Plant.

In order that the conditions of the experiment might conform as nearly as possible to those in actual practice, what is known as the "cylinder method" was adopted. A full description of the plant has already been published*, and the diagram of experiments only is republished here.

*Annual Report N. J. Station, 1899, pages 104-106, inclusive.

Diagram of Experiment.

Series.	A	B	C
1. Check	○	○	○
2. Minerals	○	○	○
3. Manure, solid, fresh	○	○	○
4. Manure, solid and liquid, fresh	○	○	○
5. Manure, solid, leached	○	○	○
6. Manure, solid and liquid, leached	○	○	○
7. Nitrate of soda, 5 gms	○	○	○
8. Nitrate of soda, 10 gms	○	○	○
9. Manure, solid, fresh; nitrate, 5 gms	○	○	○
10. Manure, solid, fresh; nitrate, 10 gms	○	○	○
11. Manure, solid and liqnid, fresh; nitrate, 5 gms	○	○	○
12. Manure, solid and liquid, fresh; nitrate, 10 gms	○	○	○
13. Manure, solid, leached; nitrate, 5 gms	○	○	○
14. Manure, solid, leached; nitrate, 10 gms	○	○	○
15. Manure, solid and liquid, leached; nitrate, 5 gms	○	○	○
16. Manure, solid and liquid, leached; nitrate, 10 gms	○	○	○
17. Sulfate of ammonia	○	○	○
18. Dried blood	○	○	○
19. Manure, solid, leached; sulfate of ammonia	○	○	○
20. [illegible]	○	○	○

PLAN OF EXPERIMENTS.

Application of Manures and Fertilizers.

On April 26th, 1900, the manures and fertilizers were applied. The manures were carefully weighed and thoroughly incorporated with the soil. About one-half of the soil was first removed from the cylinder; a portion of the manure was then taken and mixed as carefully as possible with the remaining soil, then manure and soil added from time to time until all of the manure had been used. About one inch of soil was placed upon the surface of the whole in order to prevent any changes in the manure due to exposure. The commercial fertilizers were also applied at the same time and in the same way.

Amounts Applied.

It was the aim to have the different kinds of manure applied uniform in amount and slightly greater than would be used in ordinary practice, and corresponding with that frequently used in market gardening. The applications were in no case so excessive as to render the conditions different from those obtaining in good farm practice, or at the rate of 16 tons per acre.

In the case of the nitrogen in artificial forms, the nitrates only were applied in two different quantities, in the one case 5 grams per cylinder, equivalent to 160 pounds per acre, which may be regarded as a medium, and in the second, 10 grams per cylinder, equivalent to 320 pounds per acre, or a large application. This was done in order that the effect of dentrification, if any, might be more fully studied. In the case of the ammonia and blood, an amount of nitrogen equivalent to that in the larger quantities of nitrate was applied.

The Crops Grown.

After the crops were removed from the cylinders in 1899, the surface soil was kept free from weeds, and on April 28th, 1900, oats of the Clydesdale variety were planted in the group of cylinders containing the medinm clay loam. The seed was uniform in size of grain, and 100 were placed in each cylinder. The crops on all the series grew rapidly and were photographed July 5th, and harvested July 6th, on which date the grains were fully formed and in the dough stage.

After the removal of the oats, the soil was loosened, and corn planted thickly (20 grains in each cylinder), in order to gather as far as possible the residual nitrogen. The seed did not germinate well, and the millet was replanted on July 16th, and harvested when the plants on the well-manured cylinders were fully headed.

On the sandy loam cylinders a single sweet potato plant was set in each cylinder. Plants of the Jersey variety were planted in the greenhouse March 15th, slipped into cans and transplanted to the cylinders on May 18th. They started immediately, and grew well throughout the early season. The crops in both cases were carefully watched and watered three times during the season of growth, using 14 pounds in each application. The oats were supported with wire frames to keep them upright and prevent injury from winds; the leaves which dropped were gathered and included in the sample.

Very marked differences were noted in the growth of the crops. The oats in series 4, 7, 8, 11 and 12, showed the greatest vigor and most rapid growth. Those in the check series and in series 2 and 3, were yellow and sickly and grew very slowly in the early season, though proportionately more rapidly late in the season, or after the others had headed. It is believed that if the crop had been harvested a month earlier much greater gains over check plots would have been observed.

The same statements hold true for the potatoes. On September 7th the crop was harvested, and wide variations in the crops of the different series were noticed. The variations in the yields on the plots of the same series were slight, and the experiment corresponded directly with that of 1899. In a few cases in the potato experiment, such wide variations were observed as to make it inadvisable to report the results at present. The work is, however, suggestive, and enables a study of the variations that may be expected in crops of this sort.

The Results of the Oat Experiment—1900.

The accompanying table shows the actual dry matter in the different crops, the percentage of nitrogen contained in them, the gain in nitrogen due to materials added, and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by subtracting the average gain obtained on series 2, upon which minerals only were applied, from the average gain for that particular series.

As in the crops of 1898 and 1899, there was a gain in weight of the dry matter of the crops to which nitrogenous materials were applied. Series 1, to which nothing was added, and series 2, to which minerals only were added, give us some interesting figures. While the quantities of nitrogen removed by the crop from series 1 and 2 differ but little, being 1.103 grams and 1.152 grams, respectively; yet the amounts of dry matter produced from that nitrogen show striking differences. The average amount of dry matter on series 1 was 83.1 grams; on series 2 it was 110.3 grams, taking the amount of nitrogen in the crop from series 1 as 100, the nitrogen obtained from 2, would be 104, nearly; and taking the average weight of the dry matter from series 1 as 100, the average weight of the dry matter from series 2 would be 133, nearly. Evidently the plants on series 2, thanks to the abundance of available potash and phosphoric acid, were able to employ to better advantage the limited amount of nitrogen at their disposal. A more detailed study of the yields on plots 1 and 2 for the past three years is presented elsewhere in this report, and an attempt is made to explain the variations more fully. The variations in the yield of dry matter in each series are not as great as was the case in the corn in 1898, they are practically the same as in the oats in 1899. As shown in Table A, the average variation in 1898 was 15.35 per cent., the maximum being 37.8 per cent in series 2. The average variations in 1899 and 1900 were 9.6 per cent. and 9.72 per cent., respectively, and the maximum variations were 25.2 per cent. in series 17 in 1899, and 25.5 per cent. in series 3 in 1900. These results indicate that the differences in the soils were more or less equalized during the first season, and hence the more uniform results in 1899 and 1900.

Results of the Oat Experiment.

SERIES.		Nitrogen applied.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average per cent. of nitrogen recovered.
		gms.	gms.	%	gms.	gms.		
1	A	....	81.8	1.397	1.143	....	....	....
	B	....	82.6	1.318	1.085	....	....	....
	C	....	84.8	1.293	1.096	....	....	....
2	A	....	116.9	1.018	1.190	....	....	....
	B	....	106.8	1.061	1.133	(1.152)	....	....
	C	....	107.1	1.058	1.133	....	....	....
3	A	4.05	154.0	1.061	1.634	0.482	11.90	....
	B	....	155.3	1.108	1.721	0.569	14.05	10.81
	C	....	123.8	1.142	1.414	0.262	6.47	....
4	A	3.98	232.4	1.143	2.656	1.504	37.78	....
	B	....	218.3	1.069	2.227	1.075	27.01	30.60
	C	....	213.3	1.044	2.227	1.075	27.01	....
5	A	3.99	128.5	1.145	1.471	0.319	7.99	....
	B	....	121.7	1.121	1.364	0.212	5.31	7.38
	C	....	131.2	1.147	1.505	0.353	8.85	....
6	A	4.04	193.4	1.096	2.120	0.968	23.96	....
	B	....	193.7	1.067	2.067	0.915	22.65	22.06
	C	....	193.7	1.003	1.943	0.791	19.58	....
7	A	0.78	158.0	1.163	1.838	0.686	87.95	....
	B	....	166.3	1.035	1.720	0.568	72.82	80.43
	C	....	174.7	1.019	1.780	0.628	80.51	....
8	A	1.55	202.3	1.178	2.383	1.231	79.42	....
	B	....	184.0	1.252	2.304	1.152	74.32	76.30
	C	....	198.4	1.168	2.317	1.165	75.16	....
9	A	4.83	197.3	1.085	2.132	0.980	20.29	....
	B	....	189.5	1.119	2.121	0.969	20.06	19.97
	C	....	199.2	1.052	2.096	0.944	19.55	....
10	A	5.60	207.0	1.251	2.590	1.438	25.68	....
	B	....	227.2	1.316	2.991	1.838	32.82	27.99
	C	....	232.9	1.107	2.578	1.426	25.46	....
11	A	4.76	265.4	1.277	3.389	2.237	47.00	....
	B	....	260.1	1.077	2.801	1.649	34.64	41.43
	C	....	269.0	1.183	3.182	2.030	42.65	....
12	A	5.53	262.5	1.428	3.949	2.797	50.58	....
	B	....	242.2	1.436	3.478	2.326	42.06	44.68
	C	....	285.9	1.204	3.442	2.290	41.41	....
13	A	4.77	178.6	1.150	2.004	0.852	17.86	....
	B	....	1.9.8	1.143	1.941	0.789	16.54	17.50
	C	....	178.5	1.129	2.015	0.863	18.09	....
14	A	5.54	192.6	1.333	2.567	1.415	25.54	....
	B	....	206.4	1.203	2.483	1.331	24.03	24.25
	C	....	196.4	1.241	2.437	1.285	23.19	....
15	A	4.82	217.5	1.335	2.904	1.752	36.35	....
	B	....	211.5	1.236	2.624	1.472	30.54	31.71
	C	....	217.0	1.158	2.5.3	1.361	28.24	....
16	A	5.59	257.4	1.418	3.650	2.498	44.69	....
	B	....	230.4	1.420	3.272	2.120	37.75	38.32
	C	....	214.1	1.387	2.970	1.818	32.52	....
17	A	1.52	194.5	1.142	2.221	1.069	70.33	....
	B	....	178.3	1.221	2.177	1.025	67.43	68.84
	C	....	191.2	1.149	2.197	1.045	68.75	....
18	A	1.49	173.6	1.094	1.899	0.747	50.13	....
	B	....	187.3	1.060	1.985	0.833	55.91	52.15
	C	....	175.4	1.085	1.9.3	0.751	50.40	....
19	A	5.51	177.4	1.176	2.086	0.934	16.95	....
	B	....	197.9	1.235	2.444	1.292	23.50	20.63
	C	....	201.8	1.156	2.333	1.181	21.43	....
20	A	5.48	189.5	1.154	2.187	1.035	18.89	....
	B	....	179.2	1.200	2.150	0.998	18.21	19.20

TABLE A.

Greatest Variation in the Yield of Dry Matter in Each Series.

Series.	Corn—1898. Gms.	Per cent.	Oats—1899. Gms.	Per cent.	Oats—1900. Gms.	Per cent.
1	44.4	=22.7	8.7	=17.5	3.0	= 3.7
2	95.9	=37.8	4.8	= 8.5	10.1	= 9.4
3	57.4	=18.7	15.8	=21.1	31.5	=25.5
4	24.4	= 5.4	5.7	= 2.9	24.1	=11.5
5	101.3	=29.8	7.1	= 9.9	9.5	= 7.8
6	61.9	=17.2	15.1	=13.8	0.3	= 0.1
7	6.5	= 1.9	15.8	=15.2	16.7	=10.6
8	35.7	= 9.9	1.8	= 1.3	18.3	= 9.9
9	44.9	=13.1	17.3	=15.5	9.7	= 5.1
10	16.3	= 4.2	9.0	= 5.7	25.9	=12.5
11	45.3	= 9.8	6.7	= 3.2	8.9	= 3.4
12	10.0	= 2.0	28.0	=14.7	43.7	=18.0
13	115.4	=30.8	6.2	= 5.6	8.8	= 5.2
14	97.1	=23.4	22.5	=15.9	13.8	= 7.2
15	32.2	= 8.9	5.7	= 3.9	6.0	= 2.8
16	57.3	=15.8	4.7	= 2.8	43.3	=20.2
17	70.9	=21.5	25.2	=25.2	16.2	= 9.1
18	38.1	=12.5	5.0	= 4.8	13.7	= 7.9
19	33.4	= 8.2	3.7	= 2.9	24.4	=13.7
20	48.3	=13.4	2.9	= 2.5	19.5	=10.9
Average percentage variation		15.35		9.64		9.72

Average Amount of Dry Matter in Crop—1900.

Series.	Oats—grams.	Corn—grams.
1	83.1	129.2
2	110.3	127.8
3	144.4	190.4
4	218.0	179.8
5	127.1	191.0
6	193.6	152.6
7	166.3	109.5
8	194.9	121.3
9	195.0	187.8
10	222.4	209.9
11	264.8	179.6
12	263.5	193.0
13	175.2	221.3
14	198.5	198.2
15	215.3	186.2
16	233.9	185.6
17	188.0	113.5
18	178.8	126.1
19	192.3	174.1
20	189.1	176.2

As to the nitrogen content of the dry matter, the results in the main agree with those of last year. Two tendencies, at least, are indicated, namely, the production of plants rich in nitrogen, both on soils poor in nitrogen and other plant-food and on soils rich in nitrogen, and rich also in potash and phosphoric acid. Table B shows the average percentages of nitrogen contained in the crops of 1899 and 1900. In both oat crops the dry matter in series 10, 12, 14 and 16 is, with one exception, proportionately richer in nitrogen than the average of the other series; and, in the one exception also, the crops planted to secure the residual nitrogen after the oats, produced dry matter poorer in nitrogen than the average of the 19 series (series 1 being excluded). Thus the average content of nitrogen in the dry matter of the oats of 1899 was 1.407 per cent., and of the dry matter of the millet following the oats was 1.278 per cent. On the other hand, the nitrogen content of the dry matter in the oats of 1900 was 1.168 per cent., and that of the corn following, .626 per cent. The following figures present the above facts in tabulated form:

	1899.			1900.	
	Oats. Per cent.	Millet. Per cent.		Oats. Per cent.	Corn. Per cent.
Series 10	1.409	1.234		1.225	.584
" 12	2.011	1.132		1.356	.611
" 14	1.359	1.115		1.259	.594
" 16	1.509	1.493	(*1.185)	1.409	.592
Average for the oats	1.407 per cent.		Average for the oats	1.168 per cent.	
" " millet	1.278 "		" " corn	0.626 "	

It should be pointed out here that in the millet of series 16, one of the plots was defective, its yield of dry matter being only 66.6 grams as against 126.7 grams and 110.2 grams, respectively, in the other two plots. Furthermore, the nitrogen content of the dry matter on the first plot was 1.863 per cent., as against 1.165 per cent., and 1.200 per cent., respectively, on the other two plots. For these reasons we can arrive at the facts more readily by taking the average of only two of the plots in this particular series. Now, in the four series given here, there was a large amount of available nitrogen, there having been applied in each case 10 grams of nitrate of soda, besides the manure in one form or another. Similarly in series 1, there was a yield of substance richer in nitrogen than the average, as the following figures show:

*Average of two plots.

	1899 Oats. Per cent.	1899 Millet. Per cent.	1900 Oats. Per cent.	1900 Corn. Per cent.
Series 1	1 460	2.514	1.334	.667

Average for the oats. ..... 1.407 per cent. Average for the oats. ..... 1.168 per cent.
" " millet.... 1.278 " " " corn...... .626 "

These figures bear out the statement made above, that on soils poor in nitrogen, and also in potash and phosphoric acid, as well as on soils rich in available potash and phosphoric acid, and also rich in available nitrogen, there is produced under certain conditions plant substance rich in nitrogen.

In studying the data on Table B, one notices at once that the dry matter of the oat crop of 1899 was in *every* case richer in nitrogen than that of 1900, thus the average content of nitrogen in the dry matter was for all the series 1.410 per cent. in 1899, and 1.177 per cent. in 1900. Table C brings out the same fact in a somewhat different way. It shows the amount of dry matter produced from one gram of assimilated nitrogen in each series for the years 1898, 1899 and 1900. The crop of 1898 was corn, and is not comparable with the others, except in so far as to bring out the relations of the different manures to one another. The crops of 1899 and of 1900, are, however, the same; the length of their growing season was the same (April 15th to June 24th, in 1899, and April 28th to July 6th, in 1900); their treatment was the same. And yet, as shown in Table C, there was more dry matter produced from every gram of nitrogen in the crop in 1900, than there was in 1899, and that without exception. From 1 gram of nitrogen in the crop, there was produced 71.0 grams of dry matter in 1899, and 86.2 grams of dry matter in 1900, these representing the average in all the series. In other words, every gram of nitrogen in the crop produced over 21 per cent. of dry matter more in 1900 than the same amount of nitrogen produced in 1899. Moreover, not alone was there better use made of the nitrogen assimilated, but the *absolute* amount of nitrogen taken out of the soil was greater in 1900 than in 1899. The average amount taken out in each series was 2.208 grams in 1900, and 1.874 in 1899, a difference of more than 17 per cent. A comparative study of these relations is presented on Table D. This table shows that in every case but three, the absolute amount of nitrogen taken out by the oat crop of 1900 exceeded that taken out by the same crop

TABLE B.

Average Percentage of Nitrogen Contained in Dry Matter

Series.	Oats—1900. Per cent.	Oats—1899. Per cent.	Corn—1900. Per cent.	Millet—1899 Per cent.
1	1.334	1.460	.667	2.514
2	1.045	1.375	.623	1.223
3	1.104	1.345	.608	1.176
4	1.085	1.494	.622	1.160
5	1.138	1.303	.609	1.239
6	1.055	1.251	.653	1.322
7	1.072	1.268	.668	1 300
8	1.199	1.330	.641	1.425
9	1.(85	1.253	.629	1.441
10	1.225	1.409	.584	1.234
11	1.179	1.725	.619	1.291
12	1.356	2.011	.611	1.132
13	1.141	1.232	.565	1.143
14	1.259	1.359	.594	1.115
15	1.243	1.313	.615	1.256
16	1.408	1.509	.592	1.409
17	1.171	1.394	.666	1.331
18	1.079	1.366	.662	1 305
19	1.189	1.402	.659	1.283
20	1.166	1.399	.678	1.493

TABLE C.

Amount of Dry Matter Produced by One Gram of Nitrogen in the Crop.

Series.	Corn—1898. Grams.	Oats—1899. Grams.	Oats—1900. Grams.
1	123.4	68.6	74.9
2	155.6	71.6	95.7
3	133.6	74.3	90.8
4	151.7	67.7	92.1
5	151.0	64.6	87.8
6	155.9	79.7	94.7
7	131.6	78.7	93.5
8	154.7	75.1	83.4
9	150.5	80.8	92.3
10	142.1	71.2	81.8
11	141.6	57.9	84.8
12	126.2	49.7	72.7
13	148.6	80.4	88.4
14	141.9	73.7	79.5
15	145.1	76.1	91.7
16	119.6	66.2	70.9
17	143.4	67.7	85.5
18	136.7	73 2	92.7
19	137.8	71.5	84.1
20	147.8	71.7	85.8

TABLE D.

Average Amount of Nitrogen.

Series.	Oats—1899. Grams.	Oats—1900. Grams.	Excess over 1899. Grams	Per cent.
1	.789	1.108	+.319	=40.4
2	.831	1.152	+.321	=38.7
3	1.106	1.589	+.483	=43.7
4	2.938	2.370	—.568	=23.9
5	.996	1.447	+.451	=45.3
6	1.455	2.043	+.558	=40.4
7	1.422	1.797	+.375	=26.3
8	1.901	2.335	+.434	=22.8
9	1.505	2.116	+.611	=40.6
10	2.260	2.719	+.459	=20.3
11	3.635	3.124	—.511	=16.3
12	4.022	3.623	—.399	=11.0
13	1.413	1.987	+.574	=40.7
14	2.064	2.496	+.432	=20.9
15	1.978	2.347	+.369	=18.6
16	2.596	3.297	+.701	=27.0
17	1.645	2.198	+.553	=33.6
18	1.457	1.929	+.472	=32.4
19	1.829	2.288	+.459	=25.1
20	1.650	2.204	+.554	=33.6
Average	1.874	2.208		

TABLE E.

Amounts of Nitrogen Applied.

Series.	Oats—1899. Grams.	Oats—1900. Grams.	Excess over 1899. Grams.	Per cent.
1	......	......	....	......
2	......	......	....	......
3	3.32	4.05	+ .73	= 22.0
4	5.25	3.98	—1.27	= 31.9
5	1.96	3.99	+2.03	=103.6
6	4.52	4.04	—0.48	= 11.9
7	0.78	0.78	....	......
8	1.55	1.55	....	......
9	4.10	4.83	+0.73	= 17.8
10	4.87	5.60	+0.73	= 15.0
11	6.03	4.76	—1.27	= 26.7
12	6.80	5.53	—1.27	= 23.0
13	2.74	4.77	+2.03	= 74.1
14	3.51	5.54	+2.03	= 57.8
15	5.30	4.82	—0.48	= 10.0
16	6.07	5.59	—0.48	= 8.6
17	1.62	1.52	—0.10	= 6.5
18	1.55	1.49	—0.06	= 4.0
19	3.58	5.51	+1.93	= 54.0
20	3.51	5.48	+1.97	= 56.1

in 1899. As to these exceptions, it should be noted here that series 4, 11 and 12 had considerable more nitrogen applied on them in 1899 than they had in 1900. Following are the figures :

	Oats—1899.		Oats—1900.		Excess over 1900.	
	Nitrogen applied. gms.	Nitrogen in crop. gms.	Nitrogen applied. gms.	Nitrogen in crop. gms.	Nitrogen applied. %	Nitrogen in crop. %
Series 4..........	5.25	2.938	3.98	2.370	32	24
" 11..........	6.03	3.635	4.76	3.124	27	16
" 12..........	6.80	4.022	5.53	3.623	23	11

It will be seen, then, that in the three series the larger amounts applied were partly responsible for the greater absolute amounts recovered in 1899. We say *partly* advisedly, for, as will be seen later, there is still another factor which can help us to explain the problem. A further study of Table D, in conjunction with Table E, will bring out the same facts more clearly. Let us take series 1, 2, 7, 8, 17 and 18, and examine the results obtained. It is evident that these are comparable in the series named, for the treatment in each case was the same. In series 1 and 2 no nitrogen was applied, on series 7 and 8 there was applied 5 and 10 grams, respectively, of sodium nitrate, and on 17 and 18, sulphate of ammonia and dried blood were applied in the order named. Now, what do we find? We find that on series 1 and 2 there was obtained in 1900 40.4 per cent. and 37.7 per cent., respectively, more nitrogen than was obtained in 1899 from the same series. Again, on 7 and 8, there was obtained 26.3 per cent. and 22.8 per cent. more of nitrogen in 1900 than was the case in 1899, and similarly, on 17 and 18, 33.6 per cent. and 32.4 per cent. more were obtained. *And it should be noted here that in 1899 slightly* larger quantities of nitrogen were used on 17 and 18, the figures being 1.62 and 1.55 grams, as against 1.52 and 1.49 grams in 1900. Furthermore, out of the eight series (4, 6, 11, 12, 15, 16, 17 and 18) on which more nitrogen was used in 1899 than there was in 1900, only three gave a greater return of nitrogen as against the yield of 1900.

To return again to table C, it should be noted that there is a striking uniformity in the relations pointed out here. It is the proportionate amount of nitrogen in the crop as compared with the amounts of nitrate applied. In the oat crops of 1899 and 1900, the dry matter is invariably richer in nitrogen where ten grams of nitrate were used, than is the dry matter on the series where only 5 grams were used. Thus in 7 and 8 there was 1 gram of nitrogen in every

78.7 grams of dry matter for the former, and 75.1 grams for the latter. In 1900, in the same series, it was 93.5 and 83.4. In 9 and 10 it was 80.8 and 71.2 for 1899, and 92.3 and 81.8 for 1900. In 11 and 12 it was 57.9 and 49.7 in 1899, and 84.8 and 72.7 in 1900.

The same relations hold good in 13 and 14, and 15 and 16. It should also be pointed out, in connection with table C, that the solid, fresh, allowed a more economical use of the nitrogen assimilated than did the solid, leached ; and also that the solid and liquid, leached, allowed a more economical use of the nitrogen assimilated than did the solid and liquid, fresh. And, further, the nitrogen assimilated from the dried blood was more economically used in the oat crops of 1899 and 1900 than was the nitrogen assimilated from the ammonium sulphate.

Having noted the relations existing between the different manures, it is pertinent here to attempt an explanation of the problem stated above, namely, "*why was there more dry matter produced in 1900 for every gram of nitrogen assimilated than was the case in 1899?*" A comparison of the precipitation for the growing season of 1899 and 1900 will give us the information required.

Growing Season April 15th–June 24th, 1899. Precipitation in Inches.

April 16th	.29	inches.
" 26th	.06	"
May 2d	.45	"
" 3d	.07	"
" 9th	.06	"
" 11th	.55	"
" 13th	.02	"
" 14th	.01	"
" 16th	.08	"
" 17th	.45	"
" 18th	.02	"
" 19th	.03	"
" 23d	.29	"
" 28th	.08	"
" 30th	.14	"
June 9th	.23	"
" 10th	.19	"
" 16th	.26	"
" 21st	1.95	"
Total	4.88	

Growing Season April 28th–July 6th 1900. Precipitation in Inches.

May 3d	.01	inches.
" 4th	.39	"
" 5th	.03	"
" 9th	.25	"
" 13th	.20	"
" 18th	.25	"
" 19th	3.10	"
" 20th	.30	"
" 25th	.94	"
" 26th	.04	"
" 31st	.07	"
June 2d	.75	"
" 3d	.01	"
" 4th	.06	"
" 9th	.51	"
" 12th	.10	"
" 14th	.04	"
" 15th	.73	"
" 17th	.32	"
" 18th	.01	"
" 27th	.03	"
" 28th	.08	"
July 4th	.04	"
" 5th	.05	"
Total	8.31	

It will be seen that the total rainfall for the growing period was 4.88 inches in 1899, as against 8.31 inches in 1900. However, the amount given for 1899 is too high, since the oats were harvested on the 24th of June, thus making the 1.95 inches of rain that fell on the 21st of but little value to the crop. Moreover, the applications of water to the crops when they seemed to need it was not exactly the same for the two seasons. In 1899, the cylinders had water applied to them three times (about 6 quarts each time), the dates of application being June 1st, June 5th and June 17th. In 1900, there were four applications made, the same amounts being applied as in 1899, except at the fourth application, when 9 quarts were used. The dates of application were June 13th, 22d, 25th and 28th.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID PORTIONS OF FRESH MANURE.

In 1899, the problem was more complicated because of the varying quantities of nitrogen applied in the manure.* Such was not the case, however, in the crop under consideration, for the amounts of nitrogen applied in the manure were practically uniform. In every case where manure was used, enough was applied to furnish nitrogen practically equivalent to 4 grams.

1899.		1900.	
Series 3, nitrogen applied	3.32 gr.	Nitrogen applied	4.05 gr.
" 4, " "	5.25 "	" "	3.98 "
Recovered in crop 3	8.3 %.	Recovered in crop	10.81 %.
" " " 4	40.2 "	" " "	30.60 "

It appears, then, that in each case the recovery from the solid and liquid, combined, was greater than that from the solid manure alone. However, the relations are not quite the same; for in 1899 the recovery from the solid and liquid was nearly five times that from the solid alone, while in 1900, the recovery from the solid and liquid, combined, was not quite three times that from the solid alone. The fact that the comparative recovery was greater from the solid manure alone, indicates that the greater amounts of moisture rendered greater quantities available. As with the results of 1899, it is quite evident here that a large recovery may be expected from the soluble nitrogen in liquid manures.

* Twenty-first Annual Report N. J. Experiment Station.

The greater yield of dry matter over check series 2 was 31 per cent. for the solid, and 97.6 per cent. for the solid and liquid. The corresponding figures for 1899 were 35.9 per cent. and 228.8 per cent. This again indicates that with more rain the solid manure makes a better showing. It should be borne in mind, nevertheless, that the better showing for the solid and liquid manure in 1899 was due in a measure to the larger application of 5.25 grams, as against 3.98 grams in 1900.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID MANURE, LEACHED.

As in the solid and solid and liquid manure, fresh, the leached manures were applied in unequal quantities in 1899, and in practically the same quantities in 1900. Following are the figures :

	1899.		1900.	
Nitrogen applied in leached manures,	Series. 5	1.96 grams.	Series 5	3.99 grams.
" " " " "	" 6	4.52 "	" 6	4.04 "
Recovered in crop	" 5	8.4 per cent.	" 5	7.38 per cent.
" " "	" 6	18.8 "	" 6	22.06 "

The differences in recovery in the leached manures between the solid, and solid and liquid portions, are not as great as in the fresh manures. The recovery in the solid leached is proportionately somewhat less in 1900, but in the solid and liquid leached the recovery in 1900 is much greater than that in 1899. In the preceding year, however, the recovery in the leached manures is less than the recovery in the fresh manures; while the differences in recovery between the solid fresh and leached are slight, the differences between the solid and liquid, leached and fresh, are more considerable.

As to the dry matter produced, following are the figures :

	1899.		1900.
Series 5	20.9 per cent.	Series 5	15.7 per cent.
" 6	83.3 "	" 6	57.7 "

It appears from these that in 1899, the increased yield over the check plot was greater in the case of the solid, and of the solid and liquid, leached. Also here it is evident that the differences in yield from the solid and the solid and liquid, leached, are not as great as they were in 1899. Furthermore, the dry matter produced from the solid manure, leached, is proportionately richer in nitrogen than the dry matter produced from the solid and liquid manure, leached. This is true for both 1899 and 1900.

THE RELATIVE AVAILABILITY OF THE NITROGEN IN THE FORM OF NITRATE, AMMONIA AND OF ORGANIC MATTER IN DRIED BLOOD.

The same amounts of nitrate nitrogen, of ammonia and of organic nitrogen, as dried blood, were applied on the several series, as in the years 1898 and 1899. Series 8, 10, 12, 14 and 16 received each the double quantity, that is, an amount of sodium nitrate containing 1.55 grams of nitrogen; series 7 received 0.78 grams of nitrate nitrogen. On 17 and 18, enough ammonium sulfate and dried blood, respectively, were applied to furnish, approximately, the double nitrate quantity of 1.55 grams of nitrogen. The basis of comparison, therefore, will be series 8. As in 1899, the proportionate recovery from series 8 is slighter than that from series 7. The differences, however, are somewhat smaller. The amounts recovered for 7 and 8 are 75.8 per cent. and 69.0 per cent., respectively, the corresponding figures for 1900 being 80.43 and 76.30 per cent. It would seem that the heavy showers in 1900 did not wash the nitrate beyond the reach of the crop. The dry matter in 1900, as was also the case in 1899, is richer in nitrogen on series 8. In 1899 it was 1.268 per cent., series 7, and 1.330 per cent. for series 8, and in 1900, 1.072 per cent. for 7, and 1.199 per cent. for series 8. The absolute amount of nitrogen taken out is, naturally enough, greater on series 8 than it is on series 7. In 1899 it was 1.422 grams on 7, and 1.901 grams on 8; a greater proportionate increase on 7, and a greater absolute increase on 8, as was already pointed out in Table D.

The dry matter on series 17, where sulfate of ammonia was used, is richer in nitrogen than the dry matter on series 18, where dried blood was used. The corresponding figures are 1.171 per cent. for 17, and 1.079 per cent. for 18, in 1900, as compared with 1.394 per cent. for 17 and 1.366 per cent. for 18, in 1899. It will be noticed that the differences are slighter in 1899. The percentage of nitrogen recovered is greater from the ammonia than it is from the dried blood, which is in agreement with the results of 1899. As with the nitrate, the percentage recovery from the sulfate of ammonia and from the dried blood, was greater in 1900. The recovery in 1899 was 50.3 for the sulfate of ammonia, and 40.4 per cent. for the dried blood. The corresponding figures for 1900 are 68.84 per cent. and 52.15 per cent.; also due, no doubt, to a more generous supply of moisture. It thus follows that the availability of the ammonia and blood

nitrogen was increased by the greater precipitation. It is interesting to note here, that the recovery from the dried blood in 1900 was greater than that from the sulfate of ammonia in 1899, both relatively and absolutely.

THE EFFECT OF THE USE OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH AND LEACHED, WITH NITROGEN IN THE FORM OF NITRATE, OF AMMONIA AND OF ORGANIC MATTER.

The object of these combinations was not alone the study of the availability of the different forms of nitrogen when applied together; but also to determine whether the nitrogen of the nitrates applied as such, or formed from the materials applied, would be set free by the deoxidizing action of certain bacteria.* As in previous years, the clear manure, free from any admixture of litter was used, and the amount of manure applied was in no case much greater than that applied in actual practice.

By applying the different forms singly and also in combination, it becomes possible to determine, not only the comparative availability, but also the extent of denitrification, if any should take place. The results of 1898, and of 1899, have shown clearly that, thanks to the combination, the nitrogen in the different forms is even more efficient than where these forms are used singly. The reason for this we must seek in the fact that no single form is so well adapted to nourish the plant continually and uniformly as are the proper combinations. Such uniform feeding not only enables a uniform and healthy growth, but it also makes possible a more thorough utilization of the plant food made available by providing a better root system. It should also be remembered that the character of the season is an important factor in determining the relative availability of the different forms of nitrogen. A more abundant supply of moisture will tend to increase the availability of the organic forms, and will also tend to increase to a still greater extent, proportionately, the availability of the nitrogen in the different combinations. However, while the tendency is there, the combinations do not always show a proportionate increase over the forms used singly. The following table shows the actual average percentage recovery of nitrogen, when the materials

---

* N. J. Station Report 1899, pp. 97-101; 1900, pp. 100-102.

furnishing it were used singly, as well as when they were used in combination, together with the percentage increase of nitrogen from combinations of two materials, calculated from the increase obtained when they were used singly.

		1899			1900		
	No. of Series.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered in the Combinations of Materials. Per cent.	Nitrogen Recovered. Per cent.	Calculated Recovery. Per cent.	Nitrogen not Recovered in the Combinations of Material. Per cent.
Solid manure, fresh.........	3	8.3	......	......	10.81	......	......
Solid and liquid, fresh.....	4	40.2	......	......	30 60	......	......
Solid, leached................	5	8.4	......	......	7.38	......	......
Solid and liquid, leached..	6	13.8	......	......	22.06	......	......
Nitrate of Soda..............	7	75.8	......	......	80.43	......	......
Nitrate of Soda..............	8	69.0	......	......	76.30	......	......
Sulfate of Ammonia........	17	50 3	......	......	68.84	......	......
Dried Blood..................	18	40.4	......	......	52.15	......	......
7 and 3 in......................	9	16.4	21.12	22.2	19.97	22.10	9.64
8 and 3 in......................	10	29.4	27.59	......	27.99	28.95	3.32
7 and 4 in......................	11	46.5	44.74	......	41.43	38.76	......
8 and 4 in......................	12	46.8	46.71	......	44.68	43 42	......
7 and 5 in......................	13	21.3	27.59	23.0	17.50	19.33	9.47
8 and 5 in......................	14	35.1	35.15	......	24 25	26.68	9.11
7 and 6 in......................	15	21.6	22.92	5.8	31.71	31.41	......
8 and 6 in......................	16	29.1	27 89	......	38.32	37.10	......
17 and 5 in....................	19	27.9	27.35	......	20.63	24.24	14.89
18 and 5 in....................	20	23.3	22.51	......	19.20	19.56	1.84

The difference between the percentage of nitrogen actually recovered and the percentage recoverable, calculated, represents the losses due to all causes ; the difference is expressed in percentage in the last column. It appears that in 1900 the percentage recovery was greater in 9 out of 18 series, and of these 9, 6 were in series where the materials applied were used singly. This is particularly true of 6, 7, 8, 17 and 18. On the other hand, the percentage recovery is greater in 1899 in the series where the combinations of the different forms were used, that being especially noticeable in 10, 11, 12, 13, and 14. While it may be assumed that the greater availability of the nitrate, ammonia and dried blood was due in 1900 to a greater abundance of moisture, it is more difficult to determine the causes that were responsible for a slighter percentage of recovery on the series where

combinations were used. It is questionable in just how far the difference may be attributed to leaching in 1900, for the fact that the recovery from the double quantity of nitrate on series 8 was greater in that year than was the case in 1899, would indicate that but little, if any, of the nitrate nitrogen was washed beyond the reach of the plant roots. The differences in the amount of nitrogen applied may have had something to do with it; yet, even that is questionable, for the percentage recovery was slighter in 1900 on series 11 and 12, where more nitrogen was applied in 1899, as well as on series 13 and 14, where more nitrogen was applied in 1900. It is possible that the differences were due to denitrification, still for the present this is only a surmise.

As it is, the percentage of nitrogen recovered in 1900 exceeds the calculated recovery in four cases out of ten. They are series 11, with a recovery of 41.43 per cent., calculated 38.76; series 12, with a recovery of 44.68 per cent., calculated 43.42 per cent.; series 15, with a recovery of 31.71 per cent., calculated 31.41 per cent.; and series 16, with a recovery of 38.32 per cent., calculated 37.10 per cent. In series 15 and 16, where leached manure was used with nitrate, the percentage of nitrogen recovered differs to a greater extent from that of 1899. The figures for 1899 were 21.6 per cent. and 29.1 per cent., as against 31.71 per cent. and 38.23 per cent. in 1900. The losses varied from 1.84 per cent. on series 20, to 14.89 per cent. on series 19. In 1899 the maximum loss was 23 per cent. on series 13—the minimum loss, 5.8 per cent. on series 15.

That the season has much to do with the production and transformation of plant-food in the soil is brought out very graphically in the following columns, where the availabilities of the several nitrogenous substances are compared:

	Corn. 1898.	Oats. 1899.	Oats and Millet. 1899.	Oats. 1900.	Oats and Corn. 1900.
Nitrate of soda	100	100	100	100	100
Sulphate of ammonia	99.5	72.9	77.9	90.22	87.75
Dried blood	95.4	58.5	61.3	68.35	73.07
Solid manure, fresh	16.76	12.0	43.1	14.16	26.36
Solid manure, leached	37.87	12.1	46.4	9.67	21.99
Solid and liquid, fresh	49.66	58.2	88.4	40.10	51.46
Solid and liquid, leached	50.38	20.0	33.0	28.91	35.91

As was already pointed out in the report of 1900*, the superiority of the solid and liquid manure over the solid manure is brought out strikingly. Moreover, it appears from the later results that the solid manure, fresh, if anything, is superior to the solid manure, leached, which is contrary to what could be drawn from the results obtained in 1898. In 1899, the solid, fresh, and the solid, leached, showed the same rate of availability. In 1900, the solid, fresh, in the oat crop alone, and in the oats and corn taken together, shows a higher rate of availability. Similarly, in the case of the solid and liquid, fresh and leached, the availability was practically the same in 1898. It was higher for the fresh in 1899, and also in 1900.

Results of the Corn Experiment. Residual Effects.

The oats were harvested on July 6th. A few days later the soil in each cylinder was dug up and thoroughly stirred. One hundred kernels of corn were planted in each cylinder with the two-fold object of exhausting the nitrogen left over from the crop just harvested, and also of determining the influence of the residual nitrogen on plant growth. In using a considerable quantity of seed, it was intended to make the exhaustion more rapid and complete, and, at the same time, to insure greater uniformity of assimilation by eliminating to a great extent the influence of defective individual plants. By this means the average is made more truly representative.

* N. J. Station Report 1900, p. 102.

Result of the Corn Experiment.

Series.	Residual Nitrogen.	Dry Matter in Crop.	Nitrogen in Dry Matter.	Nitrogen in Crop.	Increase over Check Plot.	Per Cent. of Nitrogen Recovered.	Average Per Cent. of Residual Nitrogen Recovered.	Both Crops. Increase over Check Plot.	Both Crops. Per Cent. of Nitrogen Recovered.	Both Crops. Average.
	gms.	gms.	per ct.	gms.	gms.			gms.		
1 A		145.0	0.617	0.895						
1 B		117.3	0.691	0.810						
1 C		125.2	0.694	0.868						
2 A		135.1	0.579	0.782						
2 B		124.4	0.649	0.807	(0.794)					
2 C		124.0	0.640	0.794						
3 A	3.57	193.6	0.624	1.207	0.413	11.57		0.895	22.10	
3 B	3.48	175.9	0.605	1.064	0.270	7.76	10.02	0.839	20.72	19.78
3 C	3.79	201.7	0.596	1.201	0.407	10.74		0.669	16.52	
4 A	2.48	201.0	0.581	1.168	0.374	15.08		1.378	47.19	
4 B	2.90	178.9	0.645	1.153	0.359	12.38	11.75	1.484	36.03	38.61
4 C	2.90	159.4	0.640	1.020	0.226	7.79		1.301	32.61	
5 A	3.67	224.4	0.577	1.294	0.500	13.62		0.819	20.68	
5 B	3.78	176.9	0.589	1.055	0.261	6.90	9.86	0.478	11.65	16.50
5 C	3.64	169.8	0.662	1.124	0.330	9.07		0.688	17.12	
6 A	3.07	162.2	0.603	0.977	0.183	5.96		1.151	28.49	
6 B	3.12	155.9	0.627	0.978	0.184	5.90	6.25	1.099	27.20	26.94
6 C	3.25	139.8	0.729	1.018	0.224	6.89		1.016	25.12	
7 A	0.11	126.7	0.660	0.836	0.042	38.18		0.728	93.33	
7 B	0.21	108.9	0.660	0.685	0.109			0.459	58.85	72.22
7 C	0.15	98.0	0.685	0.671	0.123			0.508	64.49	
8 A	0.82	125.1	0.618	0.773	0.021			1.210	78.06	
8 B	0.40	133.0	0.630	0.838	0.044	11.00		1.196	77.16	75.03
8 C	0.38	105.7	0.674	0.712	0.082			1.033	69.87	
9 A	3.85	215.4	0.618	1.330	0.536	13.92		1.516	31.39	
9 B	3.86	189.6	0.601	1.139	0.345	8.95	9.91	1.314	27.20	27.89
9 C	3.89	158.5	0.670	1.061	0.267	6.86		1.211	25.07	
10 A	4.16	202.2	0.575	1.162	0.368	8.85		1.306	32.25	
10 B	3.76	237.8	0.573	1.361	0.567	15.08	10.80	2.445	42.95	35.66
10 C	4.17	189.8	0.605	1.147	0.353	8.47		1.779	31.77	
11 A	2.52	187.8	0.633	1.188	0.394	15.63		2.631	55.27	
11 B	3.11	185.1	0.627	1.160	0.366	11.77	11.56	2.085	42.83	48.14
11 C	2.73	166.0	0.598	0.993	0.199	7.29		2.229	46.58	
12 A	2.73	225.0	0.591	1.330	0.536	19.63		3.333	60.27	
12 B	3.20	183.6	0.645	1.184	0.390	12.19	12.92	2.716	49.11	51.62
12 C	3.24	170.4	0.598	1.019	0.225	6.94		2.515	45.48	
13 A	3.92	255.3	0.527	1.344	0.550	14.03		1.402	29.39	
13 B	3.98	182.4	0.578	1.052	0.258	6.48	11.42	1.047	21.95	26.90
13 C	3.91	226.3	0.589	1.332	0.538	13.76		1.401	29.37	
14 A	4.12	224.8	0.556	1.250	0.456	11.07		1.371	33.77	
14 B	4.21	195.6	0.608	1.190	0.396	9.41	9.03	1.727	31.17	31.07
14 C	4.25	174.3	0.617	1.075	0.281	6.61		1.566	28.27	
15 A	3.07	200.0	0.588	1.177	0.383	12.47		2.185	44.29	
15 B	3.35	185.9	0.606	1.127	0.333	9.94	10.66	1.805	37.45	38.95
15 C	3.46	172.3	0.652	1.125	0.331	9.57		1.692	35.10	
16 A	3.09	206.6	0.555	1.146	0.352	11.39		2.350	50.98	
16 B	3.47	189.7	0.580	1.099	0.305	8.79	8.95	2.425	43.88	43.60
16 C	3.77	160.5	0.611	1.046	0.252	6.68		2.070	37.03	
17 A	0.45	115.9	0.649	0.752	0.042			1.027	67.57	
17 B	0.49	131.3	0.621	0.819	0.025	5.10		1.050	69.08	65.84
17 C	0.47	92.7	0.728	0.674	0.120			0.925	60.86	
18 A	0.74	137.2	0.646	0.886	0.092	12.43		0.889	55.81	
18 B	0.66	120.6	0.670	0.808	0.014	2.12	5.48	0.847	56.85	54.83
18 C	0.74	120.5	0.671	0.808	0.014	1.89		0.765	51.84	
19 A	4.58	173.7	0.652	1.132	0.338	7.38		1.272	23.09	
19 B	4.22	174.1	0.654	1.139	0.345	8.18	8.08	1.337	29.71	27.02
19 C	4.33	174.6	0.670	1.170	0.376	8.68		1.357	28.26	
20 A	4.44	182.9	0.667	1.220	0.426	9.60		1.461	26.66	
20 B	4.48	174.9	0.677	1.184	0.390	8.71	9.02	1.388	25.33	26.48
20 C	4.36	170.7	0.689	1.175	0.381	8.74		1.504	27.45	

Amount of Residual Nitrogen and Proportion Recovered.

Series.	Millet—1899. Taken out by the Oats.	Residual Nitrogen. Grams.	Average Per Cent. of Residual Nitrogen Recovered. Per cent.	Corn—1900. Taken out by the Oats.	Residual Nitrogen. Grams.	Average Per Cent. of Residual Nitrogen Recovered. Per cent.
1	......	......	......	......	......	......
2	......	......	......	......	......	......
3	8.3	3.04	17.5	10.81	3.61	10.02
4	40.2	3.14	15.9	30.60	2.76	11.75
5	8.4	1.80	19.2	7.38	3.70	9.86
6	13.8	3.90	5.5	22.06	3.15	6.25
7	75.8	0.19	......	80.42	0.16	......
8	69.0	0.48	......	76 30	0.37	......
9	16.4	3.43	12 7	19.97	3.87	9.91
10	29.4	3.44	17.8	27.99	4 03	10.80
11	46.5	3.23	16.8	41.43	2.79	11.56
12	46 8	3.61	21.8	44.68	3.06	12.92
13	21.3	2.16	6.8	17.50	3.94	11.42
14	35.1	2.28	10.6	24.25	4.19	9.03
15	21.6	4.16	5.9	31.71	3.29	10.66
16	29.1	4.31	6.9	38 32	3.44	8.95
17	50.3	0.81	......	68 84	0.47	......
18	40.4	0.92	......	52.15	0.71	5.48
19	27.9	2.58	7.5	20.63	4 38	8.08
20	23.3	2.69	11.1	19.20	4.43	9.02
Average		2 56	12.6		2.91	9.71

The figures again bring out the *facts already noted in 1899. In* all cases where manure had been applied, the plants were enabled to secure a larger amount of nitrogen than those on the check plot. More than that, the series where solid manure alone was applied, yielded more nitrogen in the residual crop, as compared with the series on which solid and liquid manure was applied. On the other hand, there was no gain over the check plot from the nitrate of soda and sulfate of ammonia, in fact, there was even a slight loss. In the case of the dried blood, there was a small gain over the check plot. Hence it may be said here that there was no *residual* effect from the nitrate and the ammonia, and a very slight effect from the dried blood. Owing to a more uniform germination of the seed, the corn produced results also more uniform as compared with the millet of 1899. It will be observed that the yield of nitrogen on series 2 was

even slighter than that on series 1, differing in this respect from the millet. Also this crop shows a percentage of nitrogen higher than the average in the dry matter on all of the series where there was no residual effect, as well as on the first two series, where no nitrogen was applied. Of the residual nitrogen, proportionately less was recovered in 1900. There was on the average, 2.56 grams of residual nitrogen in each series in 1899, and 2.91 grams in 1900. Of that, there was recovered 12.6 per cent. in 1899, and 9.71 per cent. in 1900. The last figures represent the average per cent. recovery from fourteen series in 1899, and from fifteen series in 1900.

THE AVAILABILITY OF THE RESIDUAL NITROGEN IN THE SOLID AND IN THE SOLID AND LIQUID PORTIONS OF FRESH MANURE, AND ALSO OF LEACHED MANURES.

In 1899 there was 3.04 grams of residual nitrogen on series 3, and 3.14 grams on series 4, when the oats were harvested. In 1900, there was 3.61 grams of residual nitrogen on series 3, and 2.76 grams on series 4. Of that nitrogen, there was recovered by the millet 17.8 per cent. on series 3, and 15.9 per cent. on series 4 ; while the corn recovered 10.02 per cent. on series 3, and 11.75 per cent. on series 4. It appears that the recovery in 1899 was greater than that in 1900, and furthermore the solid manure does not make as good a showing in 1900, as compared with the solid and liquid manure. This is applicable to both the fresh and leached manure. Thus the recovery from the solid and liquid manure, fresh, was greater, relatively, than the recovery from the solid manure, which is contrary to the experiience of 1899. However, tables F and G show that the absolute amounts of nitrogen furnished by the solid manure to the residual crops are greater than those supplied by the solid and liquid portions. The same is true of the leached manures. The solid portion yielded in 1899, 1.398 grams of nitrogen, the solid and liquid portions yielded in 1899, 1.269 grams. The corresponding figures for 1900 are 1.158 grams for the solid, leached, and .991 grams for the solid and liquid, leached. In 5 and 6 the residual nitrogen was in 1899, 1.80 grams and 3.90 grams, respectively, and of that there was recovered 19.2 per cent. for 5, and 5.5 per cent. for 6. In 1900 the residual nitrogen amounted to 3.70 grams in 5, and 3.15 in 6, and of that there was yielded in the corn 9.86 per cent. for 5, and 6.25 per cent. for 6. As in the previous year the varying amounts of residual nitrogen rend-

ered the problem more complicated, for all that, it appears that the greater the proportionate amount of soluble nitrogen in the manure applied, the smaller the amount of nitrogen recovered in the residual crop. Of the manure applied in 1899, there was contained in the solid portion .073 per cent. of soluble nitrogen, and in the solid and liquid portion .220 per cent. of soluble nitrogen. The residnal crop obtained from series 3, on the average, 1.582 grams of nitrogen and from series 4, on the average, 1.558 grams of nitrogen, notwithstanding the fact that there was applied on 4, 5.25 grams of nitrogen, as against 3.32 grams on series 3. Similarly, in 1900, the solid portion, fresh, contained .066 per cent. of soluble nitrogen, and the solid and liquid portion, fresh, .269 per cent. of soluble nitrogen. The residual crop obtained from 3, 1.157 grams of nitrogen and from series 4, 1.114 grams of nitrogen ; the same relations hold true, even more markedly, in the leached manures. The reason for the above is quite apparent if we consider that it is the soluble nitrogen in the manure that is rapidly changed, and having once undergone the change it is like nitrate, in that it is largely lost to the crop if not taken up within a short time. The figures clearly indicate that there is no residnal effect from the nitrate, and hence the more rapidly a given manure is nitrified, the smaller, everything else being equal, will be its residual effect. It should also be noted here that in the case of the solid, leached, the residual crop appropriated more nitrogen than the first crop. This is true of both the millet and the corn. Subtracting the amount of nitrogen obtained from the check plots, we find that the oats in 1900 obtained from the solid manure, leached, .295 grams of nitrogen, while the corn following the oats obtained from the residue .364 grams of nitrogen. Similarly, the oats in 1899 obtained from series 5, .165 grams of nitrogen, while the millet following the oats obtained .346 grams of nitrogen.

TABLE F.

Nitrogen in the Corn of 1900—The Study of Residual Effects.

Series.	Average Weight of Nitrogen in Crop. Grams.	Average Per Cent of Nitrogen in Crop. Per cent.
1	.858	.667
2	.794	.629
3	1.157	.608
4	1.114	.622
5	1.158	.609
6	.991	.653
7	.731	.668
8	.774	.641
9	1.177	.629
10	1.223	.584
11	1.114	.619
12	1.178	.611
13	1 243	.565
14	1.172	.594
15	1.143	.615
16	1.097	.592
17	.748	.666
18	.834	.662
19	1.147	.659
20	1.193	.678

TABLE G.

Nitrogen in the Millet of 1899—The Study of Residual Effects.

Series.	Average Weight of Nitrogen in Crop. Grams.	Average Per Cent. of Nitrogen in Crop. Per cent.
1	1.000	2.514
2	1.052	1.223
3	1.582	1.176
4	1.558	1.160
5	1.398	1.239
6	1.269	1.322
7	.878	1.304
8	.854	1.425
9	1.487	1.441
10	1.661	1.234
11	1.598	1.291
12	1.834	1.132
13	1.199	1.143
14	1.292	1.115
15	1.296	1.256
16	1.347	1.409
17	.948	1.301
18	.961	1.305
19	1.245	1.283
20	1.352	1.493

THE AVAILABILITY OF THE RESIDUAL NITROGEN IN THE FORM OF NITRATE, OF AMMONIA, AND OF ORGANIC MATTER IN DRIED BLOOD.

It was already noted that from the nitrate, both 5 and 10 grams, and from the ammonia no residual effect was obtained. The yield of nitrogen, on series 2, was .799 grams. On series 7, where 5 grams of nitrogen were applied, the yield was .731 grams. ; and on series 8, with the double quantity of nitrate, the yield of nitrogen in the crop was .774. So that there was actually less nitrogen gathered by the residual crop from 7 and 8 than there was from the blank series. A similar observation was made in 1899, and the explanation seems to be that with the aid of the minerals and the nitrate, stronger plants are developed on 7 and 8 than there are on 2, and these because of their better developed root system are enabled to get more nitrogen out of the soil itself and thus leave it poorer. This view is supported by a comparison of the yields on series 1 and 2. It will be noticed that the residual corn crop obtained more nitrogen from series 1 than it did from series 2. Now, no nitrogen has been added to either for three years, but minerals were applied on series 2, and these enabled the crops to withdraw more nitrogen from the soil, as a study of the analytical data will show. In like manner, on series 17 there was no residual effect, and the nitrogen gathered by the corn was only .748 grams, less than that obtained from series 2. Above all things it seems clear that no residual effect need be expected from ammonium sulfate. And it should be remembered that the residual crops were planted within a few days after the oat crops were harvested. On series 18 there was a slight gain over series 2, indicating that there was at least a small residue of nitrogen left for the corn. In 1899 no such effect was observed on 18, and should further experience prove that there is some residual effect from dried blood it can by no means be very great. Hence, as in 1899, we are confronted by the fact that although but 52.15 per cent. of nitrogen was recovered from the amount applied as dried blood, but 68.84 per cent. from that applied as sulfate of ammonia, and but 76.30 per cent. from that applied as nitrate ; no further benefit to succeeding crops need be expected from those particular applications. If anything, the availability of these three forms of nitrogen was slightly exaggerated, because of the greater amounts of nitrogen taken out of the soil with their co-operation, nitrogen that was credited to them.

THE EFFECT OF THE USE OF THE SOLID AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH AND LEACHED, ALONE, AND WITH NITROGEN IN THE FORM OF NITRATE, OF AMMONIA AND OF ORGANIC MATTER.

In the table submitted below are given the amounts of nitrogen applied, the percentage of the applied nitrogen recovered in the residual crop, the residual nitrogen after that crop, and the percentage of nitrogen obtained from the residue by the residual crop.

TABLE H.

No. of Series.	Total Nitrogen Applied. Grams.	Nitrogen Recovered. Per cent	Residual Nitrogen. Grams.	Nitrogen Recovered. Per cent.
3	4 05	8.96	3.61	10.02
4	3.98	8 04	2.76	11.75
5	3.99	9 12	3.70	9.86
6	4 04	4.83	3 15	6.25
7	0 78	......	0.16	......
8	1.55	.....	0.37	......
17	1.52	......	0.47	......
18	1.49	2 68	0.71	5.48
9	4 83	7.93	3 87	9.91
10	5.60	7.66	4.03	10.80
11	4.76	6.72	2 79	11.56
12	5.53	6 94	3.06	12.92
13	4.77	9.41	3.94	11.42
14	5.54	6 80	4.19	9 03
15	4 82	7.24	3.29	10.66
16	5.59	5.42	3.44	8.95
19	5.51	6.41	4.38	8 08
20	5.48	7.28	4.43	9 02

The relations pointed out in the last report largely hold true also this year. The recovery in the combinations does not differ much from the recovery in the manures alone, which might be expected since, as we have already found, the nitrate and ammonia show no residual effect, while the dried blood shows but a very slight residual effect. It should again be emphasized here, that the tabulated figures show less favorably for the manures used in combination than is actually the case, for as a matter of fact the recovery from the nitrate plots was less than from series 2, which was used as the standard of comparison. In 1899 the solid, leached, showed the

greatest variation in recovery, the figures being 19.2 per cent. for 5, and only 6.8 per cent. and 10.6 per cent., respectively, for 13 and 14. In 1900 the results are more uniform. The recovery for 5 is 9.86 per cent. of the residual nitrogen (table H), while the average recovery from 13, 14, 19 and 20, where 5 was used in combination with 7, 8, 17 and 18, is 9.37 per cent. Similarly the recovery from 3 is 10.02 per cent., and the average recovery from 9 and 10 is 10.35 per cent. The recovery from 4 is 11.75 per cent., and the average recovery from 11 and 12 is 12.24 per cent. In 6 the recovery was 6.25 per cent., while the average recovery in 15 and 16 was 9.80 per cent., showing a considerable increase for the two, an increase that was not quite as marked in 1899. The maximum residual recovery was 12.92 per cent. in series 12; the minimum residual recovery was 5.48 in series 18. In 1899, the maximum residual recovery was 21.8 per cent. in 12, and the minimum residual recovery 5.5 per cent. in 6.

THE AVAILABILITY OF THE NITROGEN IN THE DIFFERENT MATERIALS USED WHEN THE COMBINED RESULTS OF THE TWO CROPS, OATS AND CORN, ARE CONSIDERED.

Because of a more favorable season, the availability of the nitrate, ammonia and of the dried blood, was higher than it was in 1899. Not alone was there a greater quantity of nitrogen taken out of the check plots, but it also seems that on the nitrate, ammonia and dried blood plots there was a proportionately larger quantity taken out of the soil. This assumption is justified by the results obtained from the residual crops on the series named. It follows from this, that when the first crop is taken alone, the availability of the three forms mentioned is placed somewhat above its true value. On the other hand, the exhaustion of the humus on these series would modify the soil to such an extent as to influence the yields appreciably. It is for these reasons that the returns from the combinations cannot be expected to be almost exactly equal to the sum for the series where the materials are used singly. Aside from the slight discrepancies, however, the agreements are more than satisfactory.

From quick-acting materials immediate returns are expected and no residual effects are looked for. Hence, they are at a disadvantage when compared with slowly decaying organic materials through two or more crops. This was already pointed out in last year's report.

It was also noted then that on account of the smaller returns in the residual crop from 7, 8, 17 as compared with series 2, the percentage recovery of these materials is somewhat lowered, since the losses shown for these materials in the residual crop must be subtracted from the gains made in the oat crops. A more detailed discussion of the point in question was already presented in last year's report.* The following table shows the percentage recovery of nitrogen for all of the series when the two crops are used as the basis of calculation, as well as the calculated recovery on those series where the combination of materials was used.

	No. of Series.	Nitrogen Recovered. *Per cent.*	Calculated Recovery. *Per cent.*	Nitrogen not Recovered in the Combinations of Material. *Per cent.*
Solid manure, fresh	3	19.78	......	......
Solid and liquid, fresh	4	38.61	......	......
Solid, leached	5	16.50	......	......
Solid and liquid, leached	6	26.94	......	......
Nitrate of soda	7	72.22	......	......
Nitrate of soda	8	75.03	......	......
Sulfate of ammonia	17	65.84	......	......
Dried blood	18	54.83		......
7 and 3 in	9	27.89	28.24	1.24
8 and 3 in	10	35.66	35.07	......
7 and 4 in	11	48.14	44.14	......
8 and 4 in	12	51.62	48.84	......
7 and 5 in	13	26.90	25.60	......
8 and 5 in	14	31.07	32.87	5.48
7 and 6 in	15	38.95	34.25	......
8 and 6 in	16	43.80	40.27	......
17 and 5 in	19	27.02	30.11	10.26
18 and 5 in	20	26.48	26.92	1.63

The figures show that in six cases out of ten there was a gain on the combinations over the sum of the increase on the materials when they were used singly. Of the other four, 9 and 20 show but slight differences, and may be disregarded, on 14 and 19 the losses were 5.48 and 10.26 per cent. respectively. It is evident from the results, that there was no denitrification, and this confirms the experience of last year. The following table shows the percentage of availability of the nitrogen in the different substances, the percentage recovery of the nitrate nitrogen on series 8 being taken as 100.

*N. J. Station Report 1900, p. 108.

Oats—1900.

Nitrate of soda	100.
Sulfate of ammonia	90.22
Dried blood	68 35
Solid manure, fresh	14.16
Solid manure, leached	9.67
Solid and liquid, fresh	40.10
Solid and liquid, leached	28.91

Oats and Corn—1900.

Nitrate of soda	100
Sulfate of ammonia	87.75
Dried blood	73.07
Solid manure, fresh.	26.36
Solid manure, leached	21.99
Solid and liquid, fresh	51 46
Solid and liquid, leached	35.91

It is quite apparent that in the residual effect considered, the availability of the manure, especially the solid manures, is increased very considerably. At the same time the availability of the nitrate and of the ammonia is decreased, as was already pointed out, and therefore the relations of the different substances to one another are changed very markedly. The reason for the apparent greater availability of the solid manure, fresh, of the solid and liquid, fresh, and of the solid manure, leached, in 1899, lies not so much in the greater recovery from those manures, as in the slighter recovery from the nitrate used as the standard of comparison.

Comparison of Yields on Series I. and II.

In series I., where no applications of manure were made, and in series II., where minerals only were applied, there was a limited amount of plant-food to start with. In the series of sandy soils, that amount was still more limited, because the soil was made up of the same clay loam as in the other series, diluted by one-half its weight of sand, containing no plant-food. Now, in series II. large amounts of potash and phosphoric acid were added, so that the crops were enabled to exhaust the available nitrogen much sooner than in series I., and for this reason the yields of nitrogen from series II. were greater than those from series I. However, as time advances the differences should be less and less marked; for, according to Wagner, the yield of plant-substance from any soil is governed by that plant-

food constituent present in least quantities. In this particular case, it is the nitrogen which is present in series I. and II. in constantly diminishing quantities, and since there is a minimum amount of nitrogen absolutely necessary for the production of a given quantity of plant-snbstance, it becomes evident that no matter what the extent of the other plant-food constituents present, the yield of crop from the two plots cannot exceed a certain limit. The yields of dry matter and of the nitrogen contained in them are given below :

Series.	Corn—1898. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Average Nitrogen gms.	Oats—1899. Dry Matter in Crop. gms.	Nitrogen in Crop. gms	Average Nitrogen. gms.
I. A	240.2	1.95	1.74	54.3	.805	.789
I. B	208.0	1.47		49 7	.738	
I. C	195.8	1.80		58.4	.825	
II. A	289.6	1.79	1.87	56 7	.798	.831
II. B	253.9	1.44		60 3	.817	
II. C	329 8	2 38		61.5	.879	
	Millet—1899.			**Oats—1900.**		
I. A	24.5	.830	1 00	81.8	1 143	1.108
I. B	45.3	1 120		82.6	1.085	
I. C	54.5	1.049		84.8	1.096	
II. A	97.8	1.179	1.05	116.9	1.190	1.152
II. B	84 0	.981		106.8	1.133	
II. C	76.5	.993		107.1	1.133	

Series.	Corn—1900. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Average Nitrogen gms.
I. A	145.0	.895	.857
I. B	117.3	.810	
I. C	125.2	.868	
II. A	135.1	.782	.794
II. B	124.4	.807	
II. C	124.4	.794	

Differences in Series I. and II.

1898. gms.	1899. gms.	1899. gms.	1900. gms.	1900. gms.
.13	.042	.05	.044	—.063

In the first crop, that of 1898, there was a difference of .13 grams of nitrogen in series II. over that of series I. In 1899 there was a difference of .042 grams for the oats, and of .05 for the millet which followed the oats in the same cylinders. In 1900 there was a difference of .044 for the oats, but for the corn following the oats, there was more nitrogen taken out of series I. than there was out of series II. That might be accounted for by the fact that the abundance of potash and phosphoric acid allowed a more rapid exploitation of the

nitrogen in series II. However, that is only an assumption, further work will show in how far it follows that also subsequent crops will get less nitrogen out of series II. than out of series I.

A comparison of the figures brings out anotber interesting fact, namely, as to the amount of dry matter produced by a unit of nitrogen. The results are given in the subjoined table.

Amount of Dry Matter Produced Per Unit of Nitrogen.

Series.	Corn—1898. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Dry Matter Per Unit of Nitrogen. gms.	Oats—1899. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Dry Matter Per Unit of Nitrogen. gms.
I. A	249.2	1.95		54.3	.805	
I. B	208.0	1.47	123.4	49.7	.738	68.6
I. C	195.8	1.80		58.4	.825	
II. A	289.6	1 79		56.7	.798	
II. B	253.6	1.44	155.7	60 3	.817	71.8
II. C	329.8	2.38		61.5	.879	

Series.	Millet—1899. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Dry Matter Per Unit of Nitrogen. gms.	Oats—1900. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Dry Matter Per Unit of Nitrogen. gms.
I. A	24.5	.830		81.8	1.143	
I. B	45.3	1.120	41.4	82.6	1.085	74.9
I. C	54.5	1.049		84.8	1.096	
II. A	97.8	1.179		116.9	1.190	
II. B	84.0	.984	82.0	106.8	1.133	95.7
II. C	76.5	.993		107.1	1 133	

Series.	Corn—1900. Dry Matter in Crop. gms.	Nitrogen in Crop. gms.	Dry Matter Per Unit of Nitrogen. gms.
I. A	145.0	.895	
I. B	117.3	.810	150.7
I. C	125.2	.868	
II. A	135.1	.782	
II. B	124.4	.807	163.3
II. C	124.0	.794	

It appears, then, that, thanks to a sufficient supply of potash and phosphoric acid, the small amount of nitrogen at the dispcsal of the crop could be exploited to a greater extent. It is because of this fact that so much more dry matter was produced on series II. as against series I., although from the latter practically as much nitrogen was taken out.

A REVIEW OF THE INVESTIGATIONS CONCERNING DENITRIFICATION.

Since the beginning of these experiments in the early summer of 1898, many contributions have been made toward the better understanding of the various problems of plant nutrition. Among these, the nitrogen question has been receiving the attention of many investigators, and it has been examined from the different standpoints of the soil chemist, the soil physicist and the soil bacteriologist. Much time and ingenuity have been devoted to the clearing up of that phase of the nitrogen question known as "dentrification," the destruction of the nitrates and the setting free of gaseous nitrogen. That deoxidation of combined nitrogen is liable to take place, and actually does take place in anaerobic fermentation has been known for years, but the question assumed more than a mere scientific interest since the emphatic declaration of Wagner[1] that applications of cow or horse manure to the soil are often not only unprofitable, but harmful, that, when applied together with the nitrates, they cause, by virtue of the micro-organisms contained in them, the destruction of the nitrates. More than that, the baneful effects do not stop here, for the nitrates as they are gradually formed from the organic matter of the soil are also attacked by the dentrifying bacteria, and their nitrogen set free. In a word, then, the animal manure applied is not only useless of itself, but is harmful because of its destructive effects on the oxidized nitrogen derived from other sources.

It is quite apparent that the interests involved are of great moment, that Wagner's theory, if it be borne out by practical experience, vitally concerns the man of science, the practical farmer and the world at large. And it was in the hope of contributing something to the knowledge of the subject that these experiments were planned. The scope of the work included the study of :

I. The composition of the solid and liquid portions of cow manure, fresh.

II. The composition of the solid and of the solid and liquid portions of cow manure, leached.

III. The availability of the nitrogen in the solid and in the solid and liquid portions of cow manure, fresh.

---

[1] *Wagner. Deutsche Land. Presse., Feb., 1895.*

IV. The availability of the nitrogen in the solid and in the solid and liquid portions of cow manure, leached.

V. The relative availability of the nitrogen in the form of nitrate, of ammonia and of organic matter in dried blood.

VI. The effect of the use of the solid and of the solid and liquid portions of cow manure, fresh and leached, with nitrogen in the form of nitrate, of ammonia and of organic matter.

The results obtained are definite and clearly point in one direction, in so far as the question of denitrification is concerned, and are in accord with those of other investigators. The experimental data submitted below bring out this point forcibly.

As the work progressed and the accumulated material was studied, other questions presented themselves. They concern the movement of the plant-food in the soil and in the plant, the relation of the mineral salts to the organic matter, the influence of rainfall, the rapidity of nitrification, &c. While still following the main lines of research, as indicated, the other points have been examined in so far as was practicable, and deductions drawn where the experimental data at hand warranted it. Obviously, the many factors that determine the yield of crop are closely related to one another, and a true understanding of the subject can only come with a careful study of the soil from more than one standpoint. As a recent bulletin aptly expresses it,[2] "Our first object is to determine the *controlling* factor of fertility, * * * whether and when this factor is physical, depending upon the color, texture, or structure of the soil; climatological, depending upon temperature, sunshine and rainfall; chemical, dependiug upon the absolute chemical composition, or upon a definite minimum solubility of the soil's constituents," or, we might add, bacteriological, depending upon the activity of soil organisms.

That the latter is not the least important is attested by the numerous researches on their relation to the nitrogen question, both in its constructive and destructive phases. According to Stoklasa,[3] "the assimilation of the nitrogen of the air by bacteria forms one of the most important problems of modern biological research." On the one hand, we have the symbiotic life of the B. radicicola with the plants of the leguminous family resulting in the fixation of atmospheric nitrogen; on the other hand we have organisms like clostri-

[2] Bulletin No. 70, Maryland Agr. Expt. Sta., p. 64.

[3] Die Stickstoffassimilation durch die lebende Bacterienzelle. J. Stoklasa & E. Vitek, Centr. fur Bact. und Paras, Vol. VII., (1901), No. 8, p. 257.

dium Pasterianum, which, as Winogradsky has shown, can assimilate atmospheric nitrogen independently, or Caron's *Bacillus Ellenbachi*, which, Stoklasa claims, can also assimilate atmospheric nitrogen. These, and others, probably, constantly work to preserve and increase our stock of combined nitrogen in the soil ; they are the constructive agents. At the same time, there exist in the soil, and in decaying vegetable matter, numerous micro-organisms that have the power, under the proper conditions, to break up certain nitrogen compounds, and in this process much or all of the nitrogen is returned to the atmosphere, whence it originally came, in the gaseous state ; these latter organisms are the destructive agents. It is their activities that concern the subject of our inquiry more directly, and a brief review of the more important work along these lines will help us to understand better the experimental data submitted below.

As far back as 1867, Froehde had observed[4] that the reduction of nitrates takes place, at times, when they are in contact with certain organic substances. There appeared to be a considerable number of the latter possessing such reducing properties. From that early observation, to our present knowledge, of the specific micro-organisms causing, under given conditions, the destruction of nitrates, the study of the subject, though gradual, was decidedly irregular. It was only within the last five or six years that a careful and systematic examination of the question enabled us to gain a more definite conception of the processes of denitrification. For all that, there is much that is yet obscure, and much that calls for further study. The latter is particularly true of the denitrification processes as they appear in practical agriculture ; since, as has been pointed out repeatedly, the conclusions obtained from laboratory experiments are not always applicable to actual practice, creating, as they do, abnormal conditions not encountered in the field. As with nitrification, the earlier investigators attempted to explain denitrification by purely chemical reactions, and to the French chemists largely belongs the credit for being the first to point out to us the probable bacterial character of the denitrification processes. However, some years before that Schoenbein[5] had noticed that nitrates are reduced to nitrites by fungi, and that the presence of nitrites in drinking water might indicate that it contains micro-organisms. Dr. Angus Smith, in 1867, had also noticed[6] that a reduction of nitrates with the evaporation of free nitrogen takes place in the decomposition of sewage.

[4] Jour. für pract. Chemie, 102, 1867, p. 46.

[5] Jour. für pract. Chemie, 105, 1868, p. 211.

[6] Manures and Manuring, Aikman, p. 177.

The work done since then, and leading up to the more detailed recent studies, will be briefly reviewed here. Meusel[7] observed the transformation of nitrates into nitrites in drinking water, and attributed the formation of nitrites to bacteria. Chabrier states[8] that all soils contain nitrous acid, that in dry weather nitrates accumulate at the surface, and that nitrites occur in larger quantity in the lower layers of the soil. In another place[9] he finds that there is a small loss of nitrogen (liberated as gaseous nitrogen) in nitrification. This latter fact was also observed somewbat later by Boussingault[10] and later by Pickard,[11] and snbsequently by Godlewski.[12] Jeannel[13] found that when in contact with humus, dead leaves and straw, nitrates are reduced to nitrites ; and Schloesing[14] showed that in a large bottle, whose atmosphere was kept free from oxygen, potassium nitrate was reduced to ammonia, and, also, some of the combined nitrogen was set free. Boname,[15] a year later, also came to the conclusion that nitrates are reduced in an atmosphere free from oxygen. To Schloesing, also, belongs the credit of having established[16] the fact that nitrogen is set free in the putrefactive decomposition of urine and in the lactic fermentation of sugar in the presence of potassium nitrate.

Pesci[17] noted that nitrates are reduced to nitrites when the action is allowed to go on under water, and E. W. Davy[18] observed that an excess of animal matter in solution retards nitrification. Hüfner,[19] on the other hand, decided that no gaseous nitrogen is set free in the decay of organic substances.

Deherain and Maquenne[20] had also observed the reduction of nitrates. They attributed this action to anaerobic ferments, and showed that the gases set free contained, besides carbon dioxide, also free nitrogen and nitrous oxide. About the same time Gayon and

---

[7] Annales de chim. et de physique, XXIII., (1871), p. 161.
[8] Compt. rend. 67, p. 1031.
[9] Compt. rend. 73, p. 1480.
[10] Compt rend. 76, (1873), p. 22.
[11] Jour.d agricult. practique II, 1884, p. 373.
[12] Cent. f. Bact. 1896, p. 458.
[13] Compt. rend 75 (1872), p 1244.
[14] Compt. rend. 77 (1873) pp. 203 and 353.
[15] Ann Stat. Agron (Mauritius), 1896, p. 74, Abstr. in E. S. R. 1897, p. 731.
[16] Journal de pharmacie et de chimie, 4th. series, Vol. VIII., p. 213, 1868.
[17] Berichte chem. Gesels 8, 259.
[18] Chem. Soc. Jour. (1879), p. 429.
[19] Jour f. pract. Chemie 1876, p. 292.
[20] Ann. Agron IX., p. 5 (1882).

Dupetit[21] studied the reduction of nitrates in the soil. They describe an anaerobic "ferment" capable of reducing nitrates rapidly. In this process, gaseous nitrogen is set free. They also found that the ferments need organic matter for their development, that part of the organic nitrogen is transformed into ammonia, and, perhaps, also into amido derivatives of the organic substance. Heraeus,[22] too, had observed the reduction of nitrates to nitrites and ammonia by bacteria, and Springer[23] studied what he called a "ferment," rod-shaped, rounded at the ends, and capable of reducing nitrates.

In 1886, Gayon and Dupetit[24] isolated two organisms, B. denitrificans, α and β., capable of reducing nitrates with the evolution of gaseous nitrogen. Besides these, they encountered a number of bacteria that could reduce nitrates to nitrites. According to the composition of the nutritive medium the nitrogen of the nitrates may be set free as such, or mixed with nitrous oxide. The oxygen of the nitrates not combined with the nitrogen of the nitrous oxide, unites with the carbon of the organic matter, giving carbon dioxide, which dissolves for the most part forming bicarbonate of potassium (KNO_3 being used). The culture medium containing 10 grams of potassium nitrate begins to ferment on the addition of some soil. The authors think that the decomposition of nitrates by B. denitrificans is not a true fermentation, nor a secondary phenomenon, but a "combustion of the organic matter by the nitric oxygen with the liberation of much heat, it is a type of fermentation that can take place only with the simultaneous concurrence of several chemical reactions." Kellner and Yoskii[25] found that although losses of nitrogen occur in the decay of nitrogenous organic matter, yet the losses are slight, even after the decay had progressed for a long time. Ehrenberg,[26] in a series of exhaustive experiments, showed that "neither in the presence nor absence of free oxygen; neither in solution nor in slightly moistened decaying masses permeable to gases, is elementary nitrogen set free through the agency of micro-organisms." Tacke[27] reaches a similar conclusion, while Immendorf[28] states distinctly that according

[21] Compt. rend. 1882, XDV., pp. 644 and 1865.

[22] Zeitschr. f. Hyg. und Inf. vol. I., p. 193.

[23] Ber. chem. Gesel, XVI., 1, p. 1228.

[24] Recherches sur la Reduction de nitrates par les infiiment petits, Station Agronomique de Bordeaux, Nancy, 1886.

[25] Zeitschr. f. physiol. Chemie, 1887, p. 95.

[26] Zeitschr. f. physiol. Chemie, XI., 145.

[27] Landw. Jahrbücher, Bd. 16 (1887), p. 937.

[28] Landw. Jahrbücher, 21, p. 316.

to his experiments the setting free of nitrogen from decaying organic matter is not a purely chemical process, but it is effected with the aid of micro-organisms. It will be seen from this that, while there were still adherents of the chemical theory in Germany, the belief was beginning to prevail that the destruction of nitrates is due to bacteria. Two years later Tacke[29] admits that Berthelot was right when he claimed that there are nitrogen fixing bacteria in the soil, and adds, that there are also present in the soil organisms that set free nitrogen from its compounds.

Holdefleiss[30] was led to believe that even in yard manure constantly compacted by animals, and with the oxygen thus excluded the nitrification processes take place to some extent. Hence the greatest loss through the formation of free nitrogen takes place in the manure pile and not in the stable. By compacting the manure the nitrification processes can be limited, and we must depend on mechanical treatment to delay nitrification until the manure reaches the soil. Of course, iu preventing nitrification in the manure pile, the losses of free nitrogen, due to denitrification, are largely prevented.

Leme[31] found that the addition of large quantities of fresh manure, not only stops nitrification, but that there is at first a reduction of nitrates to nitrites, and of the latter to ammonia. Breal[32] announced that many substances of organic origin, and especially straw, are the carriers of denitrifying organisms. Obviously, the discovery is of far-reaching importance. Since these organisms are carried to the manure in the litter, and later are plowed in the soil with the manure, it becomes interesting to determine to what extent denitrification takes place, either in the manure pile or in the soil. In order that denitrification might take place it is essential that nitrates be present, and we must assume that where no nitrates are applied as such, nitrification must first take place that denitrification might follow. E. W. Davy,[33] Leme,[34] Pickard,[35] Lipman,[36] and others have shown that large quantities of organic matter either retard or entirely stop nitrification, and for that reason the losses of nitrogen from fresh manure due to the destruction of nitrates cannot be great. On the other

[29] Landw. Jahsb. 18 (1889), p. 439.
[30] Holdefleiss, Der Stallmist (1889) Brealau.
[31] Naturwis Rund. V (1890), p. 291.
[32] Ann. Agron. XVIII, p. 181.
[33] Chem. Soc Jour. 35 (1879), p. 429.
[34] Natur Rund. V. (1890), p. 291.
[35] Compt. Rend. 114 (1892), p. 490.
[36] Master's Thesis, Cornell University, 1900.

hand, losses of nitrogen may take place in other ways, and there is much evidence that confirms this view.

Konig,[37] in his prize essay, stated that "the losses of nitrogen from manure due to the volatilization of ammonia appear to be slight," and he is inclined to think that the greater losses are due to the liberation of elementary nitrogen. Immendorf,[38] on the other hand, comes to the conclusion that the chief cause of the loss of combined nitrogen in manure with the usual treatment, may be attributed to the volatilization of ammonia, and finds that the formation of elementary nitrogen influences these losses only to a limited extent. Burri, Herfeldt and Stutzer[39] carried out some experimental work to decide as to the causes that lead to losses of nitrogen in decaying organic substances, especially in dung and liquid. They are led to believe that where denitrification takes place it is preceded by nitrification. Hence they conclude that "in the decay of nitrogenous organic substances there is no setting free of elementary nitrogen as long as the activity of the nitrifying organisms in the decaying substance is suppresed." On the other hand, they believe that a considerable evolution of free nitrogen may take place when nitrates are added to dung or liquid manure, or when opportunity is given to the nitrifying organisms for active development. The splitting off of free nitrogen may be caused by the reduction of nitrates, or by the action of nitrous acid or ammonia or amines. The authors point out later that denitrification is rather due to living organisms than to purely chemical reactions, as Ehrenberg[40] assumes; nitrification, they think, may run to completion without the evolution of free nitrogen, such evolution is more likely to take place in the decaying mass when the supply of oxygen is limited. In such cases the oxygen of the nitrates is utilized and the nitrogen is set free.[41] Since in the fresh manure scarcely any nitrification takes place, the denitrification cannot be considerable. In another communication the same authors suggest that the object of a rational method of conservation should not only consist in preventing the volatilization of ammonia, but also in controlling the course of fermentation so as to favor the development of bacteria that transform organic nitrogen into ammonium carbonate.

---

[37] Wie Kann der Landwirt den Stickstoffvorrat in seiner Wirtshaft erhalten und vermehren, p. 84.

[38] Jour. für Landw, 42 (1894), p. 78.

[39] Jour. für Landw. 42 (1894) p. 329.

[40] Ehrenberg, *Zeitschr. f. physiol. Chemie*, XI., 470.

[41] Ehrenberg, l. c. 445.

Following the example of Gayon and Dupetit, Burri and Stutzer were led to attempt the isolation of denitrifying organisms. The work appeared the more desirable in view of Breal's[42] discovery, already alluded to, and of a communication from Wagner that nitrate of soda yielded inadequate returns when used together with horse manure. In communicating[43] the results of their experiments, they call attention to the fact that there are but a limited number of organisms capable of oxidizing nitrogen, while of those possessing the power of reduction (deoxidation) the number is great. Of these, however, the greater part can only reduce nitrates to nitrites, and the bacteria capable of reducing nitrates to ammonia, or of setting nitrogen free, are not very numerous. Of the work not already referred to, they mention that of Deherain and Maquenne,[44] who observed that in the gases set free in denitrification there is contained, besides nitrogen, also carbon dioxide and hydrogen. Also, the work of Giltay and Aberson[45] is mentioned. The latter describe a bacillus capable of destroying large quantities of nitrate with the evolution of free nitrogen. Burri and Stutzer finally succeeded in isolating two organisms capable of reducing nitrates completely, which they named B. denitrificans I. and B. denitrificans II. Their conclusions[46] may be summed up as follows: "When oxygen is completely excluded, B. denitificans I., together with B. coli, does not cause the evolution of free nitrogen in culture solutions containing nitrate, but most of the nitrate nitrogen is reduced to nitrite nitrogen. With a limited supply of oxygen, B. denitrificans I. can develop to such an extent as to be able, together with B. coli, to cause the fermentation of nitrate with the evolution of free nitrogen. When once started, the fermentation takes its usual rapid course. B. denitrificans I. uses in this case some of the oxygen derived from the nitrates. With a liberal supply of air, B. denitrificans I., together with B. coli, causes the destruction of nitrates in the normal way. With the complete exclusion of air, B. denitrificans II. causes the destruction of nitrates in the normal manner. With a liberal supply of air, the ability of B. denitrificans II. to cause the fermentation of nitrates is diminished or entirely suppressed."

[42] Compt. rend. CXIV., p 681.

[43] Centr. f Bact., 1895, pp. 257, 350, 392, 422.

[44] Compt. rend. XCV, pp. 691, 732, 854.

[45] Extrait des Archives Neerlandaises, XXV, p. 341-361.

[46] Centr. f. Bact. 1895, p. 431.

It follows from the above that the destruction of nitrates may be favored both by the exclusion of the air from the manure pile or by the admission of air to it. In the one case the activity of B. denitrificans II. is favored, in the other that of B. denitrificans I. The authors suggest the destruction of the bacteria before the manure is put on the field. According to Marchal[47] the behavior of B. mycoides in nutritive solutions containing nitrates is rather striking. When inoculated into a solution containing glucose and about 2 gr. of KNO_3 per liter, nitrites and ammonia could be detected in a few days, and in fifteen days ammonia alone. It appears, thus, that the same organisms may exert either an oxidizing or reducing action. Both processes are intimately connected with the respiration of the organism. In one case albuminoids are normally oxidized with the aid of atmospheric oxygen, in the other, the intramolecular respiration leads to a utilization of the nitrate oxygen to oxidize the sugar.

Attempts to isolate denitrifying organisms were also made by Schirokikh.[48] He was successful in obtaining a pure culture of an organism capable of destroying nitrates. He describes it as a bacillus with rounded ends, having no vacuoles, and one and one-half to two times as long as it is wide. It is motile, though not as markedly as, for instance B. pyocyaneus.

A further study of the denitrifying organisms isolated by Burri and Stutzer[49] is contributed by Stutzer and Maul.[50] The authors finally come to the conclusion that B. denitrificans I., together with B. coli, destroy nitrates in a flask that is merely stoppered, but when air is passed through the the liquid in the flask, denitrification is not as active. Also, Ampola and Garino[51] isolated a denitrifying organism which they named B. denitrificans agilis. They found that it is capable of dertroying nitrates rapidly. In examining the gases involved they found them to consist of nitrogen and carbon dioxide, the latter being present to the extent of 15 per cent. In searching for practical means to diminish denitrification in manure, the same authors[52] decided that peat prevents denitrification by virtue of the acidity it imparts to the manure, but when the manure again becomes alkaline denitrification again takes place.

---

47 Agricult. Science, VIII., 1894, p. 574.
48 Centr. für Bact. 1896, p. 204.
49 Centr. f. Bact. 1895, pp. 257, 350, 392, 422
50 Centr. f. Bact. 1896, p. 473.
51 Centr. f. Bact. 1896, p. 670.
52 Centr. f. Bact. 1897, p. 309.

S. A. Sewerin[56] isolated 32 different organisms from horse manure, and studied 29 of these. In one case strong foaming was noticed, and it was found that there were at least two species capable of reducing nitrates completely. Further study showed that there were also 9 species capable of reducing nitrates to nitrites, 18 species being indifferent. By diluting the nitrate solution to 0.1 per cent., 2 more showed complete reduction, and still further dilution to 0.05 per cent. showed *4 more organisms capable of complete reduction*, in all 8 species. It appears, also, that proportionately larger quantities of KNO_3 than of $NaNo_3$ are reduced in a given time, and 0.6 per cent. of $NaNo_3$ appears to be the limit of reduction. The author also finds that the stirring of the soil and greater æratiou tend to diminish denitrification.

His studies of B. denitrificans II. led Hjalmar Jensen[54] to believe that it can be grown as anaerobe. He finds a certain relatiou between the nitrate destroyed and the carbon compounds used. No denitrification takes place without a source of carbon being supplied.[55]

P. P. Deherain[56] confirms Breal's claim that there are denitrifying bacteria on straw, and Wagner's that these organisms are found in animal excreta. He finds that they occur in cultivated soils ; that the nitrogeu set free by them is accompanied by carbon dioxide, and often by nitrous oxide ; that the amount of nitrogen used by the organisms to build their tissues is comparatively small ; they utilize only the oxygen of the nitrate, and more readily exercise their reducing action in a closed space. When ordinary quantities of manure are applied, nitrification, rather than denitrification, takes place. It is hardly necessary to treat the manure with sulphuric acid to destroy the denitrifying organisms.

It has been noted above, that of denitrifying, or nitrate-destroying organisms, a large number are known at the present day, and there is no doubt that when a more thorough study is made of the subject many more will he added to the list. Thus Stoklasa[57] enumerates the following bacteria as capable of causing the fermentation of nitrates in the presence of organic acids, or of pentoses and hexoses : Bac. humosus, Bac. fluorescens lique-faciens, Bac. Pyocyaneus, Bac.

[53] Centr. f. Bact. 1897, p. 504.
[54] Centr. f. Bact. 1897, p. 554.
[55] Centr. f. Bact. 1897, p. 622.
[56] Ann. Agron. 23, p. 49.
[57] Centr. für Bact. und Paras, VII (*1901*), No. *8*, p. 260.

denitrificans, Bac. coli commune, Bac. Stutzeri, and many others that have been studied less carefully. As it is to be expected, these organisms do not possess the power of denitrification in an equal degree. The author just referred to, says that the analysis of the gas produced by B. Hartlebii showed 70 to 96 per cent. of nitrate nitrogen set free, the rest having been transformed into organic nitrogen. Furthermore, the destructive fermentation of nitrates depends to a great extent on the character of the organic acids in the nutritive *medium, some being much better adapted than others to furnish the* necessary energy for the breaking down of the nitrates. Stoklasa also claims that most of the denitrifying bacteria can cause no reduction of nitrates in media where chemically pure d-lavulose and d-galactose are present. The nitrate, he believes, is first reduced to ammonia and that is oxidized with the liberation of free nitrogen. However, not all of the ammonia is thus oxidized, for a part of its nitrogen is transformed into the organic form, a fact that was long ago noticed by Schloesing.[58] An interesting study of several manure bacteria and of the products of their activity is contributed by T. Severin.[59] Of the several organisms that be isolated from manure, some seem to differ materially from the others. Thus B. pyocyaneus, and what he calls B. N2 will not produce Co_2 and NH_3 from solid manure alone, but will attack it when it is mixed with liquid manure. On the other hand, one organism which the author designates as No. 1 seems to be more active in the absence of urine. This fact is significant in that it introduces a new factor in the study of the relative value of solid and of solid and liquid manure in plant nutrition. It is evident that in judging of the availability of the two forms we must bear in mind that with the solid manure alone, some of the organisms failing to find some soluble form of nitrogen (like that furnished by the liquid manure), do not multiply very fast, and hence the decomposition of the solid manure proceeds but slowly. Moreover, with a sufficient amount of soluble nitrogen to start with, these organisms multiply rapidly and finally attack the solid manure more vigorously. From this, it follows that, thanks to the presence of the liquid manure, the solid portion is decomposed more readily and its nitrogen becomes available sooner and in proportionately larger quantities than would be the case if it were left to itself. Therefore, when the solid

[58] Compt. Rend. CIX (1889), p. 423.

[59] Centr. für Bact und Paras Vol. VII. (1901), No. 11, p. 369.

and the solid and liquid portions are used together more nitrogen becomes available to the crop in a given time than would be the case when the two are used singly. But there is still another factor that should not be overlooked. It was already pointed out above, and namely, that at least one organism is known that attacks solid manure more readily in the absence of liquid manure. Assuming that the latter organism were to find conditions favorable for its development, it would decompose more solid manure in a given time, and in the absence of the liquid portion, than it would in a mixture of the two, and from this it follows that as far as this particular organism is concerned, more nitrogen would become available to the crop in a given time where the two are used separately. Under what conditions one organism will develop to the exclusion of the others, and what the most favorable conditions are in either case, is not definitely known. Severin found that after one organism is allowed to multiply in a sample of manure for a length of time, and the manure then re-inoculated with another organism, or with a fresh culture of the same organism, their activity is very limited and soon ceases altogether. The sterilization of the manure and re-inoculation seem to help matters a little, but even then the fermentation is not as active as in a fresh sample, and soon it diminishes rapidly until it is scarcely perceptible. These facts indicate that in the course of bacterial activity certain products are formed that are injurious to the bacteria themselves, and that sterilization does not destroy these products to any great extent. The author also observes that two organisms, when inoculated into the sterile sample of manure, produce more ammonia and carbon dioxide in a given time, in other words, decompose more organic matter than they would when acting singly. Whatever conclusions may be drawn from the above facts, it is clear that there are many factors to reckon with in the study of animal manures, and that our knowledge of some of these factors is decidedly scanty.

Some of the accumulated facts bearing on the conditions most suitable for the growth and development of the denitrifying bacteria we owe to Stutzer. In a recent article[69] he claims that denitrification in nutritive solutions is not favored by glucose, but is promoted by the presence of salts of organic acids, like potassium lactate or potassium nitrate. The reason for this be attributes to the fact that glucose is not as suitable for furnishing the molecular energy required

[69] *Neue Untersuchungen über die Wirkung der salpeterzerstörenden Bacterien in Nahrlösungen.* A. Stutzer, Centr. f. Bact. VII. (1901), No. 3, p 81.

for the breaking down of the nitrates as are the salts of organic acids. He tried four different organisms, and found that they possess the power of denitrification in a different degree. Their action on the different meat extracts in the market is also variable. Stutzer reports, for instance, that B. Hartlebii was the only organism that could destroy nitrates in a medium containing Liebig's meat extract. "Why is it," he asks, "that B. nitrovous, B. agilis and B. Stutzeri could find the necessary energy for the destruction of nitrates in a solution of potassium lactate, and not in a solution of glucose?" "Is the difference due to chemical constitution of the compounds in question, or is the ionization of the molecules the important factor?" It has been noticed that some nutritive materials serve better for the purpose of denitrification when they are first inoculated with certain non-denitrifying bacteria, sterilized after a certain length of time, and re-inoculated with the denitrifying organisms. Of these non-denitrifying organisms, B. subtilis, B. prodigiosus, B. lactis aerogenes and B. mycoides, modified the nutritive solutions so as to make them better adapted for the denitrifying bacteria, while B. megatherium seemed to be indifferent in this respect.

Turning to the more practical side of the denitrification question, we find that much thought has been given to it. Some years ago the experimental data at hand were so contradictory, and the points to be cleared up so numerous, that Pfeiffer was led to say: "There is scarcely another field of research in agricultural chemistry in which we encounter contradictions as numerous, and as fully unexplained." In order to clear up these contradictions, and to throw more light on the doubtful results, the German Agricultural Association called for a united effort on the part of the German Experiment Stations, offering, at the same time, to place the necessary means at their disposal. The call was answered and the work undertaken by the Experimental Stations of Augsburg, Darmstadt, Jena and Rostock, and, later on, by the Bonn and Gottingen Stations.[61] The investigation was to answer two general questions:

1. How are the great losses of nitrogen that take place in the decay of organic substances to be explained? "To what extent is the nitrogen liberated in the elementary state, and to what extent as ammonia, and how does the liberation of the first take place?

"2. What means do we possess of checking these losses, and how does the material thus employed act?"

[61] Die Landwistsh. Vers. Stat. 48 (1896), p. 189.

The publication of the results was to be delayed until the existing uncertainty were cleared up. Since such was far from being the case in 1896, it was decided to publish the results already received by that time, for they contain much that is valuable, and are in many respects conclusive. In accordance with this, there appeared in the Landwirt-schaftlichen Versuchs-Stationen[62] the reports of B. E. Dietzel-Augsburg, of Th. Pfeiffer, E. Franke, C. Götze and H. Thurmann-Jena, and of J. Aeby, R. Dorsch, Dr. Matz and P. Wagner-Darmstadt. The combined reports make a very valuable contribution to the subject of denitrification, and will well repay a careful study to all who are interested in the nitrogen question. In this place we can only review the general conclusions reached by the different investigators.

Dietzel[63] found that no loss of nitrogen takes place in mixtures of solid excreta and litter, or of urine and litter, provided that there is no access of air. With the admission of air, losses do take place, and these are diminished by conservation materials. The production of ammonia from solid manure alone is but slight, while the nitrogen of the liquid manure was almost entirely converted into ammonia in the presence of conservation materials. The experiments of Street[64] are in accord with Dietzel's results, for Street also finds a large increase in ammonia nitrogen in the presence of conservation materials.

The experiments of Pfeiffer, Franke, Götze and Thurmann are more extensive.[65] They make note of Ehrenberg's careful experiments[66] where he finds that no elementary nitrogen is set free from decaying organic matter, except when nitrates are present with a limited supply of oxygen. They also point out that their results are in agreement with the observations of Konig and others,[67] who states that "the losses of nitrogen from manure due to the volatilization of ammonia are but slight, and that the losses of nitrogen in its elementary form are of great extent." The authors state that they make their statement with a certain reserve in view of Immendorff's[68] claim that: "The chief cause for the loss of combined nitrogen from

---

[62] Land. Vers. Stat. 48 (1896).
[63] Land. Vers. Stat. 48 (1896), p. 177.
[64] Rep N. J. Expt. Stat., p. 94.
[65] Landw. Vers. Stat. 48 (1896), p. 189.
[66] Zeitschr. für physiol. Chemie, XI., p. 471.
[67] König, Stickstoffvorrat, p. 84.
[68] Jour. für Landw. 1894, p. 78.

manure, as it is usually treated, is due to the volatilization of ammonia," and that "the formation of elementary nitrogen plays but a subordinate part in these losses." This claim they regard as somewhat premature. The current belief that nitrification takes place in the upper layers, *the nitrates formed (are) diffused downward and* there destroyed by the denitrifying organisms, they find not to be in accord with all of the facts observed, for they found that in some cases nitrogen disappears from decaying masses even when there is a plentiful supply of air. The amount of nitrates found in manure is never great, and there is a possibility, they think, that elementary nitrogen may be liberated without the intermediate formation of nitrates, for free nitrogen could be formed directly in the oxidation of ammonia, as in their experiments there were greater losses of nitrogen in almost every case where there was a more liberal supply of oxygen. Whether in these oxidation processes nitric acid is first formed and in contact with ammonia or amines causes the liberation of nitrogen, or whether the ammonia is oxidized directly, cannot be decided."

The results of the experiments of Pfeiffer, Franke, Götze and Thurmann, may be summed up in the following general conclusions:

1. The loss of nitrogen and of organic substance with a limited access of air does not reach high limits.

2. The greater the access of air, both in point of time and quantity, the greater the loss of nitrogen. In some cases the loss may be as much as 42.6 per cent. of the amount originally applied.

3. Conservation materials give indefinite results. They do not appear to stop the loss of nitrogen entirely.

4. This is an argument in favor of the better mechanical care of manure.

5. At temperatures of 32 to 34°, as against ordinary room temperature, the loss of nitrogen did not increase much.

6. Under certain conditions nitrogen can be set free from its compounds in the elementary form entirely. This was the case in most of our experiments, and the loss in this way amounted to as much as 42.6 per cent. of the entire amount originally present.

7. Losses of ammonia, even on the addition of burnt lime, were comparatively small.

8. Losses of nitrogen in its elementary form can take place in two ways: (a) denitrification; (b) oxidation of the ammonia. In our conservation experiments the losses most probably took place as under (b).

9. Denitrification can take place with free access of air.

10. The action for a short time of 2 per cent. of burnt lime, on horse manure, apparently destroyed its denitrifying power; 3 per cent. of calcium carbonate, or 0.5 per cent. of sulphuric acid, seemed to be ineffective in this respect.

In the vegetation experiments, the action for 24 hours of 3 per cent. of burnt lime, and of 5 per cent. of marl on fresh cow manure, seemed to limit its denitrifying power.

11. The oxidation of ammonia, with the liberation of free nitrogen, is apparently due to micro-organisms.

12. The oxidation of ammonia is stopped by the addition of acid phosphate, provided there is enough of the latter present to neutralize all of the ammonia. Smaller quantities of acid phosphate have not, under the conditions of the experiment, limited the losses of free nitrogen in accordance with their ammonia-binding power.

13. The addition of burnt lime or of calcium carbonate to fermenting manure, at room temperature, stopped the liberation of elementary nitrogen almost entirely; most probably by killing the denitrifying bacteria.

14. The most favorable results obtained by the application of the different lime preparations as regards the limiting of denitrification, and of the oxidation of ammonia, lead to the following[69] conclusions: (a) The favorable action of lime is usually ascribed to its promoting nitrification. It is possible that its favorable action is partly due to the role it plays in stopping denitfrication. (b) The layering of manure with burnt lime or marl would limit the liberation of nitrogen, while covering the surface of the manure pile with soil would stop the loss of the volatilized ammonia.

15. The ammoniacal fermentation was not diminished even on the the addition of larger quantities of lime or acid phosphate, in fact, it increased in most cases. The addition of 1 per cent. of sulphuric acid decreased it but slightly.

The experiments of Aeby, Dorsh, Matz and Wagner, are described by the latter in his usual luminous style. The vegetation experiments were carried out in cylindrical pots, the different series containing 7 Kg., 18.5 Kg., 3.4 Kg., and 6 Kg. of soil. In every case enough mineral plant food was added to furnish a maximum amount. The general conclusions reached by the authors are as follows:

1. The relative availability of stable-manure nitrogen is considerably smaller than that of ammonia, nitrate and green plant-substance.

---

[69] Land. Vers. Stat. 48 (1896), pp. 247-360.

2. The nitrogen contained in solid animal excreta and in straw acts very slowly; by far the greatest portion of it is transformed into humus derived from organic substance and changes very gradually into ammonia and nitric acid.

3. The nitrogen contained in the liquid manure changes very *rapidly, at ordinary room temperature in 48 hours, into ammonia.* The addition of solid manure and of straw hastens considerably the ammoniacal fermentation.

4. Because of its rapid action and its relative availability, the liquid manure nitrogen may be considered equal to ammonia *nitrogen.*

5. When a rapidly growing crop is planted immediately after a heavy application of fresh solid manure a diminished yield may result.

6. The diminution in yield after an application of solid manure is *due to the liberation of elementary nitrogen, brought about by the* manure, and may be observed where active nitrogen (solid nitrogen, liquid manure nitrogen, green manure nitrogen, ammonia nitrogen, and nitrate nitrogen) is at the disposal of the plants.

7. The liberation of elementary nitrogen brought about by solid *manure can be traced to denitrifying bacteria,* which occur in solid animal excreta, especially in those of the horse, in great number.

8. Not alone fresh excreta, but also stable manure, possesses denitrifying properties.

9. About 100 grams of horse manure mixed with 1 liter of water *and 3 grams of sodium nitrate,* and exposed to room-temperature, caused, in 8 to 14 days, the liberation of all of the nitrate nitrogen in the elementary form.

10. The liberation of gaseous nitrogen, at least very slowly, takes place when a humus-containing field or garden soil acts on a nitrate solution.

11. Nitrogen is set free, at least very slowly, when cereal straw is in contact with a nitrate solution.

12. The nitrate destroying power of humus-containing soil, and of cereal straw is very much increased when soil and straw together are placed in contact with a nitrate solution.

13. The nitrate-destroying power of solid excreta is very considerably increased on the addition of straw.

14. According to theory, there should be 100 parts of liquid-mnaure nitrogen to every 100 parts of solid-manure nitrogen in stable manure. Practically, however, there are only 25 to 35 parts of liquid-manure

nitrogen to every 100 parts of solid-manure and straw nitrogen ; often not more than 10 parts of urine nitrogen.

The reason for this is to be sought in the following considerations : (*a*) In many stables the liquid manure does not find its way to the manure heap in its entire quantity, for a part of it flows into the pit. (*b*) A part of the liquid manure nitrogen is lost by the volatilization of ammonia. (*c*) A part of the liquid-manure nitrogen is lost as *elementary nitrogen, the loss being caused by bacteria.*

15. In the conservation of manure, the object is to find ways and means through which : (*a*) The ammoniacal fermentation in manure, or (*b*) the volatilization of ammonia from urine and manure, or (*c*) the activity of the denitrifying organisms may be prevented.

16. The formation of ammonia in a mixture of solid excreta and straw is so gradual that for practical purposes it need not be considered in the conservation of manure. Solid excreta and straw are to be considered in the conservation of manure only in so far as they influence the decomposition processes of the liquid-manure nitrogen and its transformation.

17. When a mixture of solid excreta and straw are placed in layers 80 to 100 cm. thick, the changes that take place are slight, even when it is thus exposed for 12 months, provided that the mass is well compacted, that is, the access of air largely excluded. If, on the other hand, the mass is loosened so that the air has free access to it, decomposition and transformation processes come into play, the humification of the manure takes place with a rise of temperature, and the loss in organic substance may amount to as much as 50 per cent. The ordinary conservation materials (gypsum, superphosphate, superphosphate gypsum, kainit), as well as burnt lime, when used in ordinary quantities do not appear to exert an appreciable *influence on the humification process.*

18. As the humification of the manure advances, its nitrate-destroying power diminishes in proportion, yet it does not disappear entirely, even in far-reaching humification. While it is probable that the more favorable action of well-rotted, dark-colored manure, observed in practical experience, as over against that of fresh manure, is due in the main to the diminished nitrate-destroying power caused by decay, yet an artificially-hastened humification offers no practical method for the conservation of manure.

19. *Additions* of customary *quantities* of the conservation substances named above, in the customary way, exert no influence on the diminution of the nitrate-destroying power that takes place in the

course of humification. Only on prolonged exposure and far-reaching humification of the manure could it be shown that gypsum, superphosphate gypsum and kainit, modified the nitrate-destroying power of the manure ; on the other hand, the addition of burnt lime produced a diminution of the nitrate-destroying power.

20. By the proper treatment of manure with carbon bisulphide, it is possible to reduce its nitrate-destroying power to a minimum. Nevertheless, the amount of carbon bisulphide required, and the length of time it should act, make it unavailable as a conservation agent.

21. Free sulphuric acid on the one hand, and copper sulphate on the other, are substances by means of which the activity of the manure bacteria can be energetically combatted, and it remains to be proved whether these substances can be successfully used in the practical conservation of manure.

It will be noticed that the Jena and Darmstadt Stations have reached similar conclusions in regard to certain phenomena. The experiments of both indicate that with a limited supply of air in the manure the losses of elementary nitrogen and of organic substance are not very extensive. Conversely, the greater the access of air, the greater the loss of nitrogen, in some cases reaching to as much as 40 to 50 per cent. Both find that the ordinary conservation materials, when applied in the usual quantities, do not stop entirely the loss of nitrogen, that the losses of ammonia from manure are comparatively slight, that the setting free of elementary nitrogen, caused by stable manure, is due to micro-organisms in that manure, and that burnt lime is effective in stopping denitrification to a great extent. It might be added here that the results obtained at the Darmstadt Station[70] indicate that "solid excreta and straw lose their nitrogen so very slowly that no conservation materials are needed. It is only the nitrogen of urine that requires conservation."

It may be stated here that Pagnoul[71] had found that horse manure, especially in the presence of starch, tends to cause the disappearance of nitrates, but at 30° with a sufficient supply of oxygen and water, there is no loss of free nitrogen, but the conversion of nitrate into organic combinations. It should be added here, perhaps, that the same investigator had some years earlier[72] declared that ordinary quantities of horse manure do not cause denitrification in the soil.

[70] Forshungen über den relativen Düngerwert, etc., des Stallmiststickstoffs, Land. Ver. Stat. 48 (1896), p. 302.

[71] Ann. Agron. II., 1898, p. 97.

Also Ragoyski found[73] that lime largely prevents the loss of nitrogen. He used 6 kg. lots of manure made up of 61.7 per cent. of cow dung, 26.7 per cent. of urine, and 11.6 per cent. of straw, and exposed in glass cylinders. In the manure that was untreated, there was a loss (in 56 days) of 36.6 per cent. of the nitrogen originally present. The treatment with 1 per cent. of a mixture of sulphuric and hydro-fluosilicic acids reduced the loss to 4.7 per cent.; where lime and soil were used as a covering there was an actual gain in nitrogen in one case, and in another case the loss was reduced to 7 per cent. In the manure that was treated, he finds a gain in albuminoid nitrogen. The treatment with the 1 per cent. of acid mixture *showed a gain in albuminoid nitrogen of 26.6 per cent., the treatment* with lime and soil gave a gain of 33 to 38.5 per cent., and there was a gain of 41.2 per cent. where the soil was mixed with the manure. When further tested by vegetation experiments, the author found that the nitrogen thus formed was not assimilable to the mustard crop. It is very likely that the increase in albuminoid nitrogen was due to the activity of bacteria, for also Street[74] and others have found this to be the case; but as to the availability of the organic nitrogen thus formed, there is a considerable difference of opinion. Nobbe and Hiltner[75] state definitely that the organic nitrogen produced by soil bacteria is not available, at least not immediately available, to the growing crop.

Pfeiffer, Franke, Lemmermann, and Schilbach[76] studied the availability of the nitrogen in different nitrogenous materials in both pot and field experiments. The substances used were nitrate of soda, sulphate of ammonia, ground horn, dried blood, meat and bone, and barnyard manure, both treated and untreated. Their experimental results may be stated briefly as follows:

1. Horn meal, dried blood and stable manure show a better rate of nitrogen availability in a three year cylinder experiment than is shown by the similar investigations of Wagner—

---

[73] Ann. Agron. 25 (1899), pp. 244–248.

[74] N. J. Expt. Stat. Rep. 1900, p. 87.

[75] Land. Vers. Stat. 45 (1895), p. 159.

[76] Die Wirkung des organischen Stickstoffs, speciell des Stallmiststickstoffs bei der Düngung. Land. Vers. Stat. 51 (1899), p. 249.

Availability of Nitrogen in (N. in $NaNo_3$ = 100).

	According to Pfeiffer, etc.	According to Wagner.
Horn Meal	83 - 87 per cent.	63 per cent.
Dried Blood	85 "	69 "
Stable Manure, 1	46 } 49 "	32 "
" " 2	56	
" " 3	45	

2. The residual effect of these substances is a considerable one, and our experiments were so planned as to bring out this fact. The difference in the character of the soil used may have contributed to the differences obtained.

3. Two experimental series on field plots with manure, one which averaged for the three years in cylinders an availability of 46, led to the values 92 and 93 ($NaNo_3 = 100$) in the same period.

4. A better aeration of the soil leads in cylinders to a better exploitation of the manure nitrogen.

5. In the field plots the aeration must be better than in the cylinders, because of the circulation of water and the faster drying of the upper surface. The decomposition of the barnyard manure is, therefore, hastened, bringing about a better exploitation of the nitrogen.

6. The residual effect of the barnyard manure was apparent on plots containing a light, sandy soil in the second crop of the second year; but was no longer so in the third year. On the heavy Rothamsted soil, the after effect of the manure nitrogen could be seen distinctly after twenty-three years. These differences can be explained by the varying aeration, causing a more or less rapid decomposition of the manure. Hence, the different results obtained by us as compared with those of Wagner, especially as to the much better exploitation of manure nitrogen may be accounted for in this way.

For these and other reasons, *general* conclusions cannot be drawn from our results.

8. Since the manure nitrogen on the field plots showed almost as high an availability as the nitrate of soda nitrogen, it follows that notwithstanding an application of 600 D. centners per hectar, there was no denitrification to any appreciable extent.

9. It is impossible to decide, with certainty, as to the extent of the denitrification processes in the cylinders. It is likely that on account of the more limited aeration greater quantities of nitrogen were set

free, which would account for the slighter availability of the nitrogen. We consider ourselves justified in thinking that there was not sufficient denitrification in the manure used to account for the small availability of the manure nitrogen.

It would not be out of place here to examine a certain statement of the authors that had a direct bearing on facts brought out in our own experimental work. They attempt to account for the high nitrogen content of plants grown on a soil poor in nitrogen.[77] Quoting Maerker's explanation[78] "that on a soil very poor in nitrogen the plants starving for want of nitrogen do not pass their period of infancy; on account of their lack of nitrogen they are not able to form sufficient amounts of carbohydrates, and these result in abnormal plants, which die before they mature, and, therefore, are rich in nitrogen, while containing but a small amount of dry matter." The authors criticise this statement, and point out that there must have been some other controlling factor, for with a plentiful supply of the other plant-food constituents there should result a mass of plant-food substance of normal composition. A comparison of series 1 and 2, in our experiments, will show that they are right in this respect.

In an article entitled[79] "The Cause and Significance of the Decomposition of Nitrates in the Soil," Krüger and Schneidewind report the results of their experiments. The work was undertaken in order to solve the following problems: (*a*) Does the loosening of the soil, caused by applications of manure, have anything to do with the diminution in yield? (*b*) Is it caused by the addition of organisms that destroy nitrates? Or (*c*) is it caused by the addition of substances which favor the development of the nitrate-destroying organisms, and thereby favor denitrification?

The investigation included both plot and field experiments, 6 kilos of soil being used in the former. They find that there was denitrification in the pots, there being in every case a smaller yield over the nitrate alone when, together with the latter, fresh manure is used, and that with varying quantities of nitrates. However, as the amounts of nitrate increased, the proportionate loss became smaller until it reached a certain limit, when it became practically constant. The loosening effect on the soil is not responsible, they conclude, for the

---

[77] Land. Vers. Stat. 51 (1899), p. 258.

[78] Jahrbuch der Versuch Station, Halle II., 1896, p. 59.

[79] Ursache und Bedertung der Salpeterzerstörung in Boden, Land. Jahrb. 28, (1899), p. 217.

decrease in yield. To determine the other points with certainty, the manure was sterilized. Its application did not show much change for the better, and leads to the assumption that the denitrifying effects of manure are not due to the bacteria added by it to the soil, but rather to the substances in the manure favorable for the growth and development of these organisms. This belief was strengthened by the fact that where both manure and soil were sterilized there was no destruction of nitrates. It appears, further, that the addition of pentosans produces an active fermentation in nitrate solutions, that crude fiber does not cause as violent a fermentation, but that in the end the losses are about the same. Denitrification was caused by the addition of straw ; its action being the more intense the finer the state of division. Peat seems to differ in this respect from straw and shavings, for it does not cause denitrification. Proportionately high amounts of moisture seem to favor denitrification ; smaller amounts seem to be indifferent in this respect, even to the extent of 20 per cent. Nor does the rapidity of evaporation influence denitrification one way or another. An attempt was also made to determine whether the thickness of planting is a factor. The following amounts of nitrogen were taken out of the soil :

By 100 plants	.942 grams.
" 50 "	1.197 "
" 25 "	1.247 "

It would appear that where there were fewer plants, the root systems of each was better developed and, in consequence, better use was made of the plant-food in the soil. In their laboratory experiments, where flasks without soil were used, the denitrification processes were extensive, and it was noted, as was the experience of Street and Ragoyski, that in every case (but one) there was a gain of organic nitrogen. The formation of ammonia, Kruger and Schneidewind found, was but slight ; and they also note that in the destruction of nitrates, small quantities of ordinary bicarbonate and of sodium carbonate were formed. Where leguminous crops are grown there is no diminution in yield on the addition of straw or manure. and it appears that conditions which are favorable to nitrification are not necessarily unfavorable to denitrification. The authors express the belief that while the denitrification processes in the field are not as extensive as they are in the cylinders, yet even in field operations the denitrification processes are of considerable significance. The decomposition of nitrates in the field is not usually noticable, because

the nitrification processes here are more intense than they are in the cylinders, and hence, denitrification is less marked. Denitrification is also masked on the addition to the field of barnyard manure, because there is more soluble nitrogen added by the latter to the soil than is destroyed by the denitrifying bacteria. "A direct conclusion as to the extent of denitrification in practice can only be obtained by determining the action of liquid manure, or of nitrate for itself, on the one hand, and on the other hand the action of either when used together with solid excreta and straw." The authors state here that they intend to carry out such a series of experiments. We might point out here that our experimental work can give adequate information in this regard, as can be ascertained by consulting the data submitted below.

Pfeiffer and Lemmermann[80] do not agree with Krüger and Schneidewind in their claim that denitrification caused by manure is due to the organic matter it adds to the soil, rather than to the bacteria contained in it. The former state distinctly "that the increase of organic substance as well as that of denitrifying bacteria unfavorably influence the exploitation of the store of nitrogen." "Hence," they further add, "stable manure in so far as it gives rise to denitrification phenomena in the soil, does so not alone in virtue of its organic matter, but *also as a carrier of bacteria*." The experiments on which this claim is based were carried out very carefully, the soil being analysed before and after every experiment, to determine the gain or loss of nitrogen in the soil, and thus secure a direct check on the final balance. In some cases, however, the experimental error was too great to allow a definite conclusion. With 29 Kilos of soil, they believed to have conditions more nearly like those in the field, for with smaller amounts of soil the variations in temperature, moisture, etc., produced differences great enough to make the results inapplicable to actual practice.

Maerker had pointed out[81] that in the course of sterilization of manure, certain substances are formed that are injurious to plant life. It follows, if this be true, that a comparison in vegetation experiments of sterilized and unsterilized manure would not bring out the actual relations. To avoid this difficulty, Pfeiffer and Lemmermann sterilized both lots, and then inoculated one of them with a pure culture of B. dentrificans II., given to them by Dr. Künnemann. They find that there is an increase in the soil nitrogen of all the cylinders

[80] Denitrification und Stalmistwirkung, Land. Vers. Stat., 54 (1900), p. 395.
[81] Jahr. Halle, II, 1896, p. 65.

on which no nitrogen had been applied, and are inclined to ascribe the cause of it to nitrogen-fixing bacteria. This view is confirmed by the experience of Aeby,[82] of Schneidewind,[83] and Richter.[84] The latter sums up his conclusions as follows: "(1). The several unsterilized vessels to which no nitrogen had been added show an increase in nitrogen. The gain is slight in the first crop, but increases later.

"(2). In all cases where nitrogen is applied, there is a loss of soil nitrogen. Hence, the increase of nitrogen in the soil takes place only when the latter is poor in assimilable nitrogen."

Pfeiffer and Lemmermann also find that there was no residual effect for the second crop on the cylinders where sodium nitrate alone was used, but where it was used with manure there was a residual effect. They attempt to account for the fact by assuming that in the presence of the manure bacteria a part of the nitrogen was converted into organic nitrogen, and the latter was utilized by the second crop. It was already pointed out above that Nobbe and Hiltner found such organic nitrogen to become available but slowly. The general conclusions are stated by the authors in the following paragraphs:

1. The unfavorable exploitation of the nitrogen store in the soil can be caused both by an increase of organic substance (source of energy), as well as of denitrifying bacteria.

2. *In so far as manuring with stable manure, solid excreta, etc.,* at all, leads to denitrification in the soil, the manurial substance produces such an effect not alone through the organic matter it contains, but also as a carrier of bacteria.

3. The hypothesis of Gerlach that only such manure can act injuriously on the accompanying application of nitrate, as will act injuriously by itself, for otherwise, the amount of energy is used up *in destroying the nitrates formed from that manure, does not agree* with the facts observed. Gerlach's own experiments, and the experiments reported here, do not justify such conclusions.

4. The injurious effects of the first factor mentioned under 1, as they were shown in the first vegetation period in the cylinder experiments, were not apparent in the second crop.

5. *The increase in organic substance by the application of a solution* of potassium citrate, as well as the addition of a pure culture of denitrifying organisms, caused the evolution of elementary nitrogen.

6. The escape of elementary nitrogen, due to the application of

---

[82] Landw. Ver. Stat. 46 (1895), p. 409.

[83] Jour. für Landw. 45 (1897), p. 185.

[84] Land. Vers. Stat. 51 (1899), p. 221.

manure, is of a minor importance as compared with the other factors leading to the unsatisfactory exploitation of the manure nitrogen.

7. The utilization of nitrate of soda on a light, sandy soil is not affected either by cow or horse manure, applied up to the rate of 800 d. centner per hectar.

8. Since the same cattle manure showed different results on field plots and cylinders, we would point here again that the results obtained from pot experiments are not always directly applicable to practicable crop-growing.

9. The variable action of the nitrogen in the different manures cannot be accounted for by their varying content of ammonia, amid, and digestible albuminoid-nitrogen, as shown by analysis.

10. The assumption that denitrification, that is, the liberation of elementary nitrogen, offers a full explanation of the varying action of the different manures, is excluded. The content in nitrogen-free organic substance, especially in pentosans (xylose), does not seem, in our experiments, to have any definite relation to the observed nitrogen action.

11. There is a difference in the rate of decomposition of the different manurial substances used by us, and in this we are inclined to find the main reason for the varying action of manure nitrogen in general.

12. In loosely-packed manure, the transformation of the nitrogen compounds into a form available to plants can be entirely suppressed, even under the most favorable decomposition that leads to an extensive decrease of the nitrogen-free organic substance. Neither ammonia nor elementary nitrogen are liberated, and even the splitting off of amides from the albuminoids takes place to a limited extent, and is concealed by the development of molds and other organisms.

13. We suspect that the phenomena mentioned under 11 and 12 are to be referred to the injurious action in the manure of proteolytic ferments; however, we must carry out further experimental work to prove this point.

14. The residual effect of manure nitrogen, which is at times very considerable, is again brought out.

15. When nitrate is applied together with manure, a part of the nitrogen of the former may be fixed, and may lead to an increased availability, or show a residual effect in the following crop.

The authors further cite instances where the decrease of crop could not be attributed to denitrification. One is taken from Schneide-

wind,[85] who applied 9 grams of nitrate nitrogen and 300 grams of straw, and found after the crop was harvested that there were still 3.3965 grams of nitrate nitrogen in the soil, notwithstanding the fact that the yield of nitrogen in this case was reduced by the straw from 3.5968 grams to 3.0634 grams. And, another instance from Krüger and Schneidewind,[86] where the yield of nitrogen was similiarly reduced from 4.873 grams to 4.498 grams, and yet there were still left in the soil 0.923 grams of nitrate nitrogen. In view of these and other facts cited, the authors believe that it is the organic substance itself, apart from any bacterial activity, that is often responsible for a diminished yield, at least in experimental work, where large quantities are used. Pfeiffer and Lemmermann are also inclined to think that since a part of the nitrate nitrogen is changed into the organic form, and is later utilized by the plant, it is manifestly unjust to decide on its relative availability from short vegetation experiments. Finally, they conclude that there are several factors responsible for the so-called denitrification process. There are at least three such factors, and namely :

1. Direct injury to the growing plants by larger quantities of organic substance.
2. Fixation of soluble nitrogen by the increased activity of different organisms.
3. Denitrification proper.

It is still to be learned which one of these factors plays the most important part economically, and how we are to modify and influence such activity.

From his more recent experiments[87] Rogoyski concludes that there is a denitrification of nitrates in the presence of large amounts of manure, the nitrogen being set free in the elementary state, while a part of it is transformed into organic combinations. Similar changes occur when soil containing lårge quantities of manure or straw is mixed with urine, or a solution of ammonia salts. The nitrogen thus fixed appears to be readily nitrifiable. When quantities used in practice were applied no denitrification took place, and the urine was nitrified. On the other hand, denitrification did take place when excessive quantities were applied.

[85] Jour. für Landw. 1897, p. 184.
[86] Landw. Jahrb. 1899, p. 221.
[87] Ann. Agron. 26 (1900), pp. 121-140.

The work of Wood[88] indicates that there was considerable denitrification when manure at the rate of 10 to 20 tons per acre was applied, together with nitrate. While there was some denitrification where well-rotted manure was used, the effects are more striking in the case of fresh manure. Thus nitrate alone gave an increase of 9½ bushels of grain per acre, while nitrate together with fresh manure gave practically no increase.

The above represents a brief review of most of the research work on denitrification and the changes in manures. The fact that great losses of nitrogen take place when excessive amounts of manure are applied, and that, conversely, no denitrification, or very little denitrification, takes place when ordinary quantities are applied; taken together with the experiments of Pfeiffer and Lemmermann, to prove that much of the reduction in yield usually attributed to denitrification is really due to the injurious effect of large amounts of organic matter, indicate that there is a phase of the subject that needs very careful investigation.

---

[88] Bd. Agr. (London), Rept. Agr. Educat. and Research, 1899–1900, pp. 124, 125.

REPORT OF THE ASSISTANT IN SOIL CHEMISTRY AND BACTERIOLOGY.

SOIL CHEMISTRY AND BACTERIOLOGY.

Since the first of July of the present year, the provision has been made for the chemical and bacteriological study of soils. The general scope of the work, as planned, is the investigation of the movements of plant-food in the soil, and the part of bacteria in the formation, change or destruction of such plant-food. Obviously, the field is extensive, with work enough for many investigators. What the details of the present investigation shall be, must be determined by the work itself. In the course of its development the attempt will be made to answer, in so far as it is possible, the questions raised.

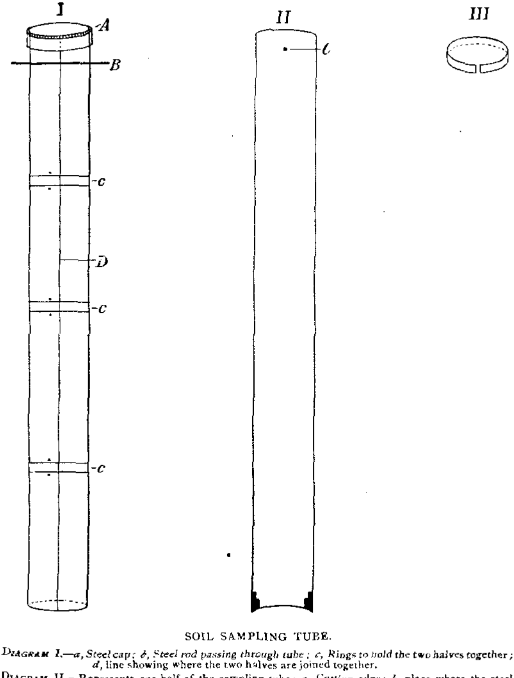
The first problem encountered in the preliminary work was that of securing representative soil samples. These are required both for analytical study and for preservation as museum specimens. The former is to include the field samples, as well as the soils of the cylinder experiments, reported in this volume. It became necessary, therefore, to design two distinct sampling tubes, each for a specific purpose. After some experimenting, two tubes were finally made that are eminently satisfactory for the purposes designated. The first of these is a brass tube one inch in internal diameter and three and one-half feet long. Its upper end is provided with a brass cap, and its lower end has soldered into it a steel ring, which is so constructed that it enables the core to slide up easily. The tube is cut in two along its entire length, the two halves being held in place by rings which are kept from sliding up or down, while the tube is in use, by two stops, one on each side of the ring. The rings are also divided so as to enable them to move past the stops when necessary, and may be compressed to fit more tightly around the tube. There is a circular hole through the tube, just a little below the cap, through which a steel rod is passed, and it serves to facilitate the boring of the tube into the soil. It should also be added, here, that the tube is graduated into inches. To secure a sample, the steel rod is passed through the head of the tube, and the latter pressed down-

ward until the desired depth is reached. The tube is then withdrawn, the cap and rings removed, and the tube being placed horizontally, one-half is taken off, exposing the core. If desired, any portion of the core representing certain depths, as indicated by the graduation, can be removed and retained for analysis. Such an arrangement makes possible the study of the plant-food in the different layers of the soil. The core taken out by this tube is small, but while it does not remove large quantities of soil from the limited amount in the cylinders, it yet furnishes enough material for the work in question.

The other sampling tube is constructed on the same principle. It is made of steel and provided with a steel cap. It is two and one-half feet long, divided like the other into two halves, which are held together by brass rings, and is two inches in internal diameter. This tube has been found very useful in the collection of soil and subsoil samples, both for analytical work and for museum specimens. In the latter case, the cores are transferred in their natural position into glass tubes of the proper dimensions, and, after being sealed and labeled, are ready for exhibition.

A preliminary survey has been made of the soils of South Jersey. The purpose in view was the study of the different soils in so far as they are typical for the growth of any particular crop. At the same time attention has been given to the geological derivation of the different soils, with the intention to determine, ultimately, the changes produced by cultivation, and the features common to the soils of any particular geological area. Thirty-six samples of soils and subsoils have been collected and prepared for analysis. At the same time they were subjected to a partial mechanical analysis, and the results thus far obtained, while they are of some significance, will be withheld from publication until more complete data are secured. The samples thus far secured range from the heavy clay soils of the marl beds to the sands and yellow gravels of the Post-Tertiary, and it is hoped that their study will yield some interesting results.

The microchemical study of soils solutions was begun. It opens a very promising field for future investigation, and may help to understand more clearly the changes that take place in the soil. The exact nature of the salts in aqueous soil solutions as they are influenced by the derivation of the soil itself, by its treatment and climatic conditions will, perhaps, be better understood by the application of such methods.



SOIL SAMPLING TUBE.

DIAGRAM I.—*a, Steel cap; b, Steel rod passing through tube; c, Rings to hold the two halves together; d*, line showing where the two halves are joined together.

DIAGRAM II.—Represents one-half of the sampling tube; *a*, Cutting edge; *b*, place where the steel rod passes through.

DIAGRAM III.—Shows one of the brass rings used to hold the tube together.

REPORT OF THE ASSISTANT IN HORTICULTURE.

REPORT OF THE ASSISTANT IN HORTICULTURE.

The work of the year has been a continuation of the various experiments outlined in previous reports, the detail of which requires, with each year, increasing attention. Fair crops have been obtained from most all the fruits and vegetables in the experimental plots. The permanent plots remain as usual, excepting that in plot 1 of the peaches, the second tree of Reeve's Favorite variety—natural fruit—was replaced. The variety Wager was also discarded, and one tree each of the new varieties, Carmen and Greensboro, planted in its place. To the list of novelties, a seedling of the Early Harvest blackberry has been added.

The rainfall records have been made as usual, and in Table 1 is given the daily and monthly precipitation for the year ending October 31st, together with the normal rainfall for this section. Table 2 contains the monthly and yearly records since January 1st, 1896, with the monthly and yearly normal.

The records show the year to have been a variable one as regards rainfall. Two months, February and June, had less than one inch, .76 and .81 inches, respectively, of rainfall, while April, July and August had nearly or quite double the normal. The lowest previous rainfall in the time covered by our records was 1.13 inches in June of 1898, and 1.41 inches in April of 1896. Up to the first of March, the first four months of the fiscal year, the rainfall was 2.74 inches below the normal, and for the year it is 2.26 above the normal.

TABLE 1.

Showing Daily and Monthly Precipitation in Inches at the College Farm for the Year Ending October 31st, 1901.

DATE.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1	T	......	......	......	......	......	0.10	......	......	......	0.16	......
2	0.12	......	......	......	0.07	......	T	......	0.48	......	0.02	......
3	0.25	......	......	......	......	1.25	0.44	0.26	0.16	......	0.01	......
4	......	1.35	......	0.57	......	0.13	......	......	0.03	0.29	......	......
5	......	0.13	......	......	0.23	0.03	......	......	0.19	......	......	......
6	......	......	......	......	......	*	......	......	0.69	0.29	......	......
7	......	......	T	......	......	1.10	......	0.47	3.40	1.92	......	......
8	0.65	......	......	......	......	......	......	......	0.04	......	......	......
9	0.40	T	......	0.17	0.19	......	0.05	......	0.16	......	......	......
10	......	......	0.32	......	0.02	......	1.05	......	......	......	......	......
11	......	T	0.51	......	2.49	......	0.50	......	0.18	0.06	0.39	......
12	......	......	0.87	......	......	......	0.21	......	0.94	0.50	0.13	......
13	......	......	......	......	......	......	0.10	......	0.09	0.10	0.03	0.52
14	......	......	......	......	......	......	......	......	0.76	......	......	1.24
15	......	......	......	......	0.14	0.33	T	0.06	T	......	......	0.13
16	......	......	......	......	0.03	0.14	......	......	......	0.31	0.09	......
17	......	......	0.02	......	......	......	......	......	......	......	0.21	0.10
18	......	......	0.03	0.02	0.01	0.01	0.49	......	0.10	1.01	0.21	......
19	......	......	T	......	......	......	......	......	......	0.35	0.04	......
20	0.05	......	......	......	0.01	0.85	......	......	......	......	0.06	......
21	0.07	......	......	......	1.34	2.35	......	......	......	1.10	......	......
22	......	0.03	0.01	T	......	0.11	......	......	......	......	......	......
23	......	0.01	......	......	......	0.03	0.12	0.02	0.09	T	......	......
24	0.14	0.02	......	......	0.13	0.65	......	......	......	2.97	......	......
25	0.74	......	0.11	......	T	0.39	0.62	......	......	......	......	......
26	1.85	......	......	......	0.37	0.02	0.21	......	0.20	......	......	......
27	......	......	......	......	0.16	......	0.59	......	......	......	......	......
28	......	0.09	......	......	......	......	0.06	......	0.02	......	......	......
29	......	......	......	......	......	......	0.36	......	0.91	......	0.51	......
30	......	......	0.12	......	......	......	0.05	......	0.55	......	......	......
31	......	0.69	0.02	......	......	......	0.06	......	0.13	......	......	T
Total, 1901	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99
Normal rainfall	3.93	3.65	3.82	3.64	3.79	3.68	4.02	3.80	4.92	4.98	3.94	3.45

* Included in that for the next day.

TABLE 2.

Showing Monthly Precipitation in Inches Since January 1st, 1896.

	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Yearly total.
Total, 1896..	....	....	1.68	5.85	5.92	1.41	3.70	4.93	4.37	2.42	4.81	1.62	*36.71
Total, 1897..	2.95	1.59	2.89	2.77	2.47	3.47	6.45	2.50	12.84	3.81	2.10	1.59	44.93
Total, 1898.	4.52	5.09	3.92	3.49	3.09	4.17	7.86	1.18	3.91	6.44	1.46	5.80	50.88
Total, 1899..	7.14	3.16	4.88	5.37	6.63	1.50	2.04	3.64	6.32	3.45	7.80	2.96	54.79
Total, 1900..	4.11	2.06	4.86	5.80	3.40	2.88	5.68	2.64	6.94	2.24	3.30	3.53	46.88
Total, 1901..	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99	49.63
Normal......	3.74	3.86	3.62	3.64	3.77	3.68	4.02	3.80	4.92	4.98	3.94	3.45	47.37

* Ten months only.

The Permanent Experiment Plots.

In order that the results may be better understood, the general plan of small fruit experiments is here repeated.

In each case, currants and gooseberries excepted, six varieties or six rows, 160 feet long and set in one block, are duplicated, giving 12 rows, of which rows 1 and 7, 2 and 8, etc., are of the same variety. Rows 7 to 12, inclusive, are irrigated as occasion demands, nothing being applied on rows 1 to 6. Lengthwise each block is divided into four equal plots 40 feet long. Those unirrigated are numbered 1 to 4, those irrigated 5 to 8. Plots 1 and 5, 2 and 6, etc., are treated identically, except that plots 5 to 8 are irrigated. The plan for currants and gooseberries is the same, except that there are only four varieties with six plots, 25 feet instead of 40 feet in length.

Table 3 shows the fertilizers, amounts and times of application to be applied to the various plots. This plan has been carefully adhered to the past season. The irrigated plots received water during the month of June, the amount applied is noted in each case.

TABLE 3.

Showing Fertilizers, Amounts and Time Applied to the Different Plots, Asparagus and Small Fruits.

KIND OF FRUIT OR VEGETABLE.	Plots 1 and 5.	Plots 2 and 6.	Plots 3 and 7.	Plots 4 and 8.
Asparagus.......	20 ts. * yard manure applied in fall.	500 lbs complete † applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash‡ applied in fall.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied when cutting ended.
Blackberries ..	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Raspberries	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Strawberries...	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P. ‡ applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P. applied in spring.
	Plots 1 and 4.	Plots 2 and 5.	Plots 3 and 6.	
Currants....	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	
Gooseberries...	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs nitrate soda applied after blossoming.	

This general arrangement of plots, fertilizers, etc., allows a study of—

a. The effect of irrigation.

b. The relative effect of fertilizers with and without irrigation.

1. Upon early yield.
2. Upon total yield.

c. The effect of the addition of nitrate of soda.

* The quantities of manure or fertilizer given are in every case the amounts per acre to be applied.

† Complete Fertilizer—a mixture of the best forms of fertilizing constituents, analyzing nitro-

ASPARAGUS.

The plantation was cultivated and crowns uncovered April 11th. Ridged up preparatory to cutting, April 29th. Cutting began May 1st, five days later than in 1900, and was continued until June 26th. Yard manure was applied to plots 1 and 5, December 4th, and at the same time bone and potash was spread on plots 3, 4, 7 and 8. April 29th, plots 2, 3, 4, 6, 7 and 8, received 500 pounds per acre of the complete fertilizer, and on June 28th, plots 4 and 8 received nitrate of soda at the rate of 200 pounds per acre. The irrigated plots, 5 to 8, received water June 17th and 24th, applying each time the equivalent of a rainfall of three-fourths of an inch.

Table 4 contains the tabulated results for the season of 1901, the totals for the seasons of 1898, 1899 and 1900, and the totals of the four seasons combined.

The results in early yields are not as uniform as in last season's crop, where Palmetto exceeded all others in seven of the eight plots. In early yield, this year, Palmetto leads on four plots, Conover's Colossal, Barr's Mammoth and Elmira in one each, and on the other the last two varieties give the same early product. The second largest early yield is given by Barr's Mammoth and Colossal, on two plots each, by Elmira on three, and by Columbian Mammoth White on one plot.

In total yield, Palmetto exceeds on all plots except 5, where Elmira gives the larger total. The same results were obtained last season, excepting that it was exceeded on plot 5 by Barr's Mammoth, instead of Elmira. Columbian Mammoth White is second in total yield on five, Barr's Mammoth on two, and Elmira on one plot.

The wholesale price of asparagus in our local market averaged 16 cents for the early and 10.48 cents for the total cut, as against 18½ cents and 10.94 cents, respectively, for last season. Combining results on all plots, the yields and value per acre of the early and total cut of the six varieties are as follows:

	Early Yield.	Value.	Total Yield.	Value.
Barr's Mammoth	186.3	$26.83	3,244.9	$306.06
Elmira	224.6	32.35	3,908.5	368.65
Columbian Mammoth White	158.2	22.78	3,163.2	298.35
Palmetto	247.6	35.66	5,421.2	487.91
Colossal	193.1	27.81	3,903.4	377.22
Giant Brunswick	63.8	9.19	2,126.7	203.99

TABLE 4.

Asparagus.—Fertilizer Plots.

VARIETY.	UNIRRIGATED											
	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth....	14.5	300.0	37.50	28.5	298.5	32.00	20.5	171.5	23.75	16.5	210.0	24.50
Donald's Elmira....	14.5	364.0	44.75	27.0	286.0	35.25	26.5	300.0	23.25	10.5	207.0	19.75
Columbian Mammoth White.......	8.5	306.5	45.00	27.0	220.0	31.75	13.0	182.0	28.25	5.0	185.5	21.75
Palmetto	8.5	497.0	51.25	25.0	403.0	44.75	12.0	391.0	41.00	17.0	332.0	40.25
Conover's Colossal.	12.5	368.0	37.50	19.5	249.0	26.25	13.5	250.5	23.25	14.5	213.0	22.50
Giant Brunswick...	5.0	203.5	26.25	11.0	189.0	28.75	4.5	131.5	15.75	7.5	140.5	29.00
Total	63.5	2039.0	242.25	133.0	1645.5	198.75	90.0	1426.5	155.25	71.0	1288.0	157.75
Totals for 1898..	68.0	238.5	156.0	95.5	231.5	113.5	76.5	176.5	108.0	67.0	158.0	61.0
Totals for 1899..	136.0	697.0	109.5	148.0	620.0	76.5	130.0	587.5	76.0	98.0	420.0	71.5
Totals for 1900..	149.5	1786.5	176.0	229.0	1540.5	118.0	182.0	1389.0	102.0	149.0	1224.0	95.0
The four years' totals combined	417.0	4761.0	683.75	605.5	4040.5	506.75	478.5	3529.5	441.25	385.0	3085.0	385.25

Asparagus.—Fertilizer Plots.

VARIETY.	IRRIGATED.											
	PLOT 5.			PLOT 6.			PLOT 7.			PLOT 8.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth....	10.0	348.0	36.75	4.5	218.5	17.25	9.0	188.0	19.00	6.0	172.5	22.75
Donald's Elmira....	14.5	367.5	44.75	22.0	325.5	36.75	10.0	218.0	24.25	7.0	229.0	41.00
Columbian Mammoth White........	5.0	259.5	41.75	18.0	295.5	25.25	14.5	227.0	28.00	7.0	183.0	31.50
Palmetto	8.5	331.0	43.25	24.0	485.0	43.25	28.5	418.0	24.50	22.0	379.0	40.25
Conover's Colossal..	18.5	342.5	41.50	11.5	367.0	37.00	12.0	253.0	34.00	11.5	251.0	27.50
Giant Brunswick...	....	122.0	24.50	8.0	165.0	24.00	1.5	184.5	23.50	5.0	135.0	28.25
Total	56.5	1770.5	232.50	88.0	1806.5	183.50	75.5	1488.5	153.25	58.5	1349.5	191.25
Totals for 1898..	72.5	224.5	137.5	100.0	288.5	111.5	84.5	196.5	108.5	77.5	164.5	81.0
Totals for 1899..	135.0	666.0	116.5	180.0	658.5	87.0	136.5	589.5	77.0	101.5	490.5	66.5
Totals for 1900..	109.5	1590.5	176.5	206.5	1544.5	136.5	200.0	1447.0	117.0	161.5	1199.0	105.0
The four years' totals combined...........	373.5	4251.5	663.00	569.5	4248.0	518.50	496.5	3721.5	455.75	389.0	3208.5	443.75

Palmetto is again the most productive sort, giving 33 pounds in early and 1,512.7 pounds in total yield more than any other. These, however, are the weights as cut in the field. Allowing 10 per cent. for waste in bunching, etc., this increase in yield is commercially worth $3.31 and $110.69 for the early and total yields, respectively. Elmira is second in value of early yield and the Colossal second in value of total product.

Considering the plots, grouping the six varieties together, we have:

a. The unirrigated plots exceed in every case in early yield those irrigated.

In total yield, plots 6, 7 and 8 exceed that of the unirrigated duplicates, while plot 1 exceeds plot 5.

The growth of tops is greater on the unirrigated plots, excepting 4, where that of plot 8, irrigated, is the larger. Combining the yields of the irrigated plots and that of those unirrigated, we find that the latter have given the larger early yield, but in the total yield and growth of tops, the irrigated plots give slightly the larger product.

b. Plots 2 and 6 (complete fertilizer only) have given the largest early cut this season, as well as in the three previous crops. With one exception, plot 1, 1898, plots 3 and 7 (complete fertilizer in spring, with bone and potash in the fall), have given the second largest early yield throughout.

In the total yields the results are the same each year, with one identical exception in 1898 and in the present season, *i. e.*, plot 6 exceeding plot 5. In order, the plots stand as numbered, 1 and 5, 2 and 6, 3 and 7 and 4 and 8, exceptions as above.

In top-growth, the results this season are variable, though 1 and 5 give the largest weight in this, as in previous years.

c. The present season, those plots receiving the additional nitrate have exceeded in early yield only plots 1 and 5. In total cut they have given the lowest yields. With the exception of the early cut upon plot 5, in the years 1898 and 1900, these plots have given the lowest yields throughout the experiment.

Combining the yields of the four crops cut from the plantation, the early yield has been greatest upon the unirrigated plots. The total yield under irrigation is slightly the larger, and in top-growth considerably larger than that on those not irrigated.

In total yield and in growth of tops, the effect of manures and fertilizers are as the plots are numbered, or in order, plots 1 and 5, 2 and 6, 3 and 7, and 4 and 8. The yield, however, of plot 6, is but 3.5 ounces less than that of plot 5—less than one ounce difference for

each crop. The early yields vary somewhat, but the order for those plots *not irrigated* is 2, 3, 1 and 4, while for those irrigated the order is 6, 7, 8 and 5. Those plots receiving nitrate of soda are lowest in all cases, excepting plot 8, early yield, where it stands third.

Table 5 contains the detailed record of the sub-irrigated row, the two rows set with selected crowns, and the two new sorts, Moore's Cross-Bred and Giant Argenteuil. This is the first season's cut for this last variety, hence the smallness of the yield. The totals for the three previous crops are also given.

TABLE 5.

Asparagus.—New Varieties and Selected Crowns.

VARIETY.	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tons.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lb
onald's Elmira	4.0	290.0	26.25	18.5	276.0	37.75	16.5	225.0	22.50	12.5	210.0	25.
almetto	15.5	402.0	55.50	20.0	329.0	35.25	10.5	325.0	42.50	5.0	288.0	44.
loore's Cross-Bred	7.0	214.0	25.50	12.0	281.0	28.25	14.0	225.0	30.50	6.0	255.0	25.
iant Argenteuil	1.0	14.0	13.50	8.0	29.0	20.50	17.0	45.0	24.50	4.5	51.0	34.
ub-irrigated row	....	....	....	*14.0*	*253.5*	*30.50*	*20.5*	*261.5*	*32.00*	*11.5*	*283.5*	*33.*
Total*	27.5	920.0	120.75	53.5	865.0	121.75	58.0	820.0	120.00	28.0	804.0	130.
Totals for 1898*	64.5	152.0	95.0	40.0	117.5	61.5	57.5	140.5	86.0	49.0	119.0	63.
Totals for 1899*	97.0	425.5	59.0	77.5	357.5	49.5	64.0	341.5	47.5	43.5	277.5	45.
Totals for 1900*	102.0	956.0	95.5	78.5	805.5	94.0	81.5	782.5	93.0	71.5	579.0	72.
he four years' totals combined	291.0	2453.5	370.25	249.5	2145.5	326.75	261.0	2084.5	346.50	192.0	1779.5	310.
ub-irrigated totals combined (1 row)	....	....	....	38.0	516.0	61.50	78.0	585.5	74.00	40.5	553.5	81.

*Sub-irrigated row not included.

The general care of these rows is identical with plots 1 to 4 of the fertilizer plots. The results for the season in early and total yield are the same as already given, *i. e.*, plots 2 and 3 in order for early yield, and plots 1, 2, 3 and 4 in order for the total yield. In growth of tops, however, plot 4, receiving the additional nitrate, exceeds all others. Also in early cut this plot exceeds that of plot 1, though

third in amount cut. The combined results for the four years are variable in early cut, and in weight of tops. In total cut, however, the results are as already given, *i. e.*, in order, plots 1, 2, 3 and 4.

The advantage derived from setting the large selected crowns has entirely disappeared. Palmetto gives identical weights in top-growth with the same variety in the permanent plot. In all other cases, the yields upon the permanent plots exceed that of the plots where selected crowns were used.

BLACKBERRIES.

Manures and fertilizers were applied as follows: Yard manure, December 4th, to plots 1 and 5, and also bone and potash to plots 3, 4, 7 and 8. May 15th, the complete fertilizer was applied on plots 2, 3, 4, 6, 7 and 8, and on June 12th, nitrate of soda given to plots 4 and 8. The plantation was trimmed the 1st of April, and May 2d the space between the rows was thoroughly cultivated. The irrigated plots received water but once this season (June 28th), when the equivalent of 1 inch of rainfall was applied.

Table 6 contains the records for the year made as in previous years, together with the totals for the crops of 1898, 1899 and 1900, and the combined totals of the four crops taken from the plantation.

The yields obtained this season are only about one-third that given last year. Of the different varieties, Early Harvest is first in total yield in four plots, Eldorado in three and Erie in one. Erie last season was first in four plots. The same varieties stand in same relation as to second best in yield on the different plots, *i. e.*, Early Harvest on four, Eldorado on three and Erie on one. Combining the yields for the different varieties upon all the plots and calculating the yields per acre, we have the following comparisons, yields given in quarts:

	Early Yield.	Total Yield.
Early Harvest	761.33 quarts.	2,156.22 quarts.
Wilson, Jr.	207.10 "	944.71 "
Erie	234.52 "	1,391.98 "
Agawam	105.40 "	960.26 "
Taylor	88.29 "	1,166.01 "
Eldorado	224.80 "	2,107.60 "

Early Harvest gave the greatest yield the past season, with Eldorado second. In 1900, Erie was first, with Early Harvest second.

TABLE 6.

Blackberries – Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED. PLOT 1. Yield first three pickings.	PLOT 1. Total yield.	PLOT 2. Yield first three pickings.	PLOT 2. Total yield.	PLOT 3. Yield first three pickings.	PLOT 3. Total yield.	PLOT 4. Yield first three pickings.	PLOT 4. Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	*July 8.*	112.0	292.0	*108.0*	279.9	95.0	*212.0*	70.0	274.0
Wilson, Jr.	" 20.	63.0	215.0	28.5	167.0	26.0	160.0	18.0	52.0
Erie	" 22.	78.0	339.0	35.0	220.0	25.0	174.0	39.5	243.0
Agawam	" 22.	5.5	37.0	10.0	186.0	15.0	100.0	28.0	218.0
Taylor	" 22.	......	36.0	36.5	245.0	7.5	192.0	5.5	209.0
Eldorado	" 20.	*18.0*	*209.0*	*38.0*	*500.0*	*19.0*	*326.0*	*36.0*	*230.0*
Total	....	271.5	1,128.0	256.0	1,597.0	187.5	1,164.0	197.0	1,226.0
Equivalent in quarts	....	*11.3*	*47.0*	*10.7*	*66.5*	*7.8*	*48.5*	*8.2*	*51.1*
Totals in quarts for 1898	....	13.3	87.4	16.4	71.5	24.4	87.2	14.8	52.1
T als in quarts for 1899	....	8.9	39.6	10.7	61.3	16.2	101.1	15.0	90.0
Totals in quarts for 1900	....	35.7	212.8	32.2	269.6	29.4	196.8	32.8	177.8
The four years' totals *combined*	....	*69.2*	*586.8*	*70.0*	*408.9*	*77.8*	*433.6*	*70.8*	*371.0*

Blackberries—Fertilizer Plots.

VARIETY.	*Date first picking.*	IRRIGATED. PLOT 5. Yield first three pickings.	PLOT 5. Total yield.	PLOT 6. Yield first three pickings.	PLOT 6. Total yield.	PLOT 7. Yield first three pickings.	PLOT 7. Total yield.	PLOT 8. Yield first three pickings.	PLOT 8. Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Early Harvest	July 8.	188.0	882.0	129.5	314.0	123.5	447.0	113.5	481.0
Wilson, Jr.	" 20.	68.0	346.0	20.0	139.0	8.0	29.0	24.0	58.0
Erie	" 22.	33.0	271.0	49.5	270.0	14.5	86.0	20.0	115.0
Agawam	" 22.	25.5	147.0	23.5	260.0	12.0	131.0	10.5	106.0
Taylor	" 22.	13.5	241.0	19.5	257.0	13.0	118.0	13.5	138.0
Eldorado	" 20.	36.0	371.0	55.0	411.0	25.0	288.0	50.5	286.0
Total	....	*364.0*	*1,761.0*	297.0	1,681.0	196.0	1,049.0	232.0	1,184.0
Equivalent in quarts	....	15.2	73.4	12.4	70.0	8.2	48.7	9.7	49.3
Totals in quarts for 1898	....	27.2	161.1	29.5	108.1	20.8	67.6	20.0	55.6
Totals in quarts for 1899	....	18.3	98.7	17.0	148.9	18.0	131.7	16.0	119.6
Totals in quarts for 1900	....	41.2	207.0	34.7	195.9	33.8	146.4	29.1	142.0
The four years' totals combined		101.0	540.2	93.6	517.9	80.8	389.4	74.8	366.5

Considering the plots, we have :

a. Plots 5 to 8, irrigated, have given the largest early yield throughout. In total yields, the irrigated plots exceed in two cases, and are exceeded in the other two by those not irrigated. Combining the four plots, those irrigated exceed those not irrigated by almost 11 per cent.

b. In early yield, the same results were obtained as in last year's crop, *i. e.*, plots 1 and 5 first, with 2 and 6 second. In total yield, the results are irregular, plots 2 and 5, 4 and 6, 3 and 8, 1 and 7 being the order of productiveness the past season.

c. Those plots, 4 and 8, receiving the extra nitrate of soda are third in early yield, exceeding only plots 3 and 7, and in total yields 4 is second, where not irrigated, and 8 is third of those irrigated.

Combining the results of the four crops removed from the plantation, the early yield under irrigation exceeds that of the unirrigated plots by 22 per cent., and in tbe total by 13.3 per cent.

The effect of the fertilizers is quite irregular, particularly where not irrigated. Here the relations are plots 3, 4, 2 and 1 in early, and 3, 2, 1 and 4 in total yields. Under irrigation, the effect in early and total yield is the same, *i. e.*, plots 5, 6, 7 and 8.

RASPBERRIES.

The work relative to the care of the raspberries was all performed upon practically the same dates as those given under blackberries. Water was applied to plots 5 to 8 twice during June (the 22d and 29th), giving each time the equivalent of an inch of rainfall.

We report this year for the first the two black caps, with the three red varieties included in previous reports.

The canes of the Cuthbert, in plots 1 and 5, were broken considerably by snow during the winter of 1900 and 1901, so that yields from these plots are somewhat reduced.

Of the varieties upon the different plots, Cuthbert gives the largest early yield in six plots, and Souhegan upon the other two. These are, however, plots 1 and 5, where the yield from Cuthbert was reduced. Cuthbert and Turner, in three plots each, have given the largest total yields, with Souhegan first in the other two. Cuthbert and Turner are second in three each, and Gregg and Soubegan in one each.

TABLE 7.

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Cuthbert	July 8.	20.5	71.0	108.5	288.0	125.0	283.0	185.0	363.0
Marlboro	" 2.	7.0	48.0	24.0	118.0	9.5	97.0	8.5	80.0
Turner	" 5.	19.0	164.0	89.0	391.0	60.0	348.0	31.5	278.0
Gregg	" 5.	34.0	181.0	22.5	82.0	30.5	98.0	25.0	76.0
Souhegan	" 2.	50.5	234.0	27.0	145.0	44.0	136.0	40.0	187.0
Total		131.0	698.0	266.0	974.0	269.0	962.0	290.0	929.0
Equivalent in quarts		6.0	31.7	12.1	44.3	12.2	43.7	13.2	42.2
Totals in quarts for 1898*		7.0	23.7	2.4	11.7	2.4	11.4	2.6	10.8
Totals in quarts for 1899*		12.4	38.4	6.1	37.2	6.0	38.3	8.0	24.2
Totals in quarts for 1900*		2.9	33.6	7.7	46.8	5.8	49.5	3.2	36.8
The four years' totals combined		28.3	127.4	28.3	140.0	26.4	142.9	22.0	113.5

*Three varieties only.

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz	oz.	oz.	oz.	oz.
Cuthbert	July 8.	51.0	142.0	94.0	212.0	129.0	288.0	120.5	289.0
Marlboro	" 2.	4.5	28.0	18.0	93.0	8.0	64.0	6.0	83.0
Turner	" 5.	29.0	235.0	58.0	304.0	25.5	287.0	30.5	266.0
Gregg	" 5.	37.5	163.0	17.0	50.0	57.0	166.0	11.0	33.0
Souhegan	" 2.	80.0	290.0	68.0	199.0	77.0	255.0	48.0	180.0
Total		202.0	858.0	250.0	858.0	296.5	1,010.0	216.0	851.0
Equivalent in quarts		9.2	39.0	11.4	39.0	13.5	45.9	9.8	38.7
Totals in quarts for 1898*		8.7	41.5	2.9	14.0	2.8	13.6	2.2	11.2
Totals in quarts for 1899*		12.0	40.6	7.8	39.8	6.0	41.5	6.0	32.2
Totals in quarts for 1900*		4.5	37.5	5.5	40.5	4.8	47.4	3.9	39.5
The four years' totals combined		34.4	158.6	27.1	132.8	27.1	148.4	21.9	121.6

Combining, as in previous cases, these five varieties give the following yields in quarts per acre :

	Early Yield.	Total Yield.
Cuthbert	102.15 quarts.	2,325.43 quarts.
Marlboro	99.28 "	753.26 "
Turner	422.34 "	2,734.74 "
Gregg	289.15 "	1,046.75 "
Souhegan	535.69 "	1,943.24 "

Considering the results by plots :

a. The irrigated plots give the largest early yield in two cases, and in total yield in one case only. Combining the yields of the plots not irrigated, and that of those irrigated, the latter give slightly larger yields both in the early and total.

b. The results with the different fertilizers are very irregular. In early yields, plots 4 and 7 are best, with 3 and 6 second. In total yields 5 and 6 are identical, plots 2 and 7 lead, with 3 and 5 and 6, second.

c. Where nitrate of soda was added to the unirrigated plots, the early yield is the largest, and in total yield, third in order. Where irrigated, it is third in early yield and lowest in total yields.

Considering the results of the four crops harvested, the irrigated plots have given yields but little larger than where no water was applied. The effect of the different fertilizers is very irregular, plot 3 being best where unirrigated, and plot 5 of those irrigated. Nitrate of soda added has given the lowest returns throughout.

CURRANTS AND GOOSEBERRIES.

Manures and fertilizers were applied to these fruits as follows : Yard manure, December 4th, to plots 1 and 4, and the bone, potash and acid phosphate mixture at the same time on plots 2, 3, 5 and 6. Nitrate of soda was applied to plots 3 and 6, May 8th. The bushes were trimmed the second week in April, and the spaces between the rows thoroughly cultivated May 1st.

The irrigated plots received water three times, June 19th, 25th and July 1st, applying the equivalent of three-fourths of an inch of rainfall the first time, and one inch the other times.

Table 8 contains the records for the year, together with that of the last three years, and the four crops combined.

TABLE 8.

Currants—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz.	oz.	oz.
Fay's Prolific	441.0	549.0	320.0	480.0	247.0	390.0
Red Dutch	732.0	603.0	830.0	809.0	818.0	717.0
Victoria	672.0	528.0	650.0	752.0	658.0	654.0
White Grape	352.0	319.0	360.0	604.0	376.0	385.0
Total	2,197.0	1,959.0	2,160.0	2,595.0	2,099.0	2,146.0
Equivalent in quarts	109.9	98.0	108.0	129.8	105.0	107.3
Totals in quarts for 1898	13.3	3.4	8.8	17.8	11.3	9.4
Totals in quarts for 1899	41.2	37.5	49.8	51.8	51.6	50.9
Totals in quarts for 1900	62.7	61.0	53.9	82.0	68.1	60.5
The four years' totals combined	227.1	199.9	220.5	281.4	236.0	228.1

Gooseberries—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz.	oz.	oz.
Downing	227.0	127.0	107.0	140.0	135.0	187.0
Columbus	228.0	144.0	118.0	203.5	160.0	202.0
Houghton	376.0	336.0	381.0	508.5	526.0	565.0
Triumph	278.0	218.0	179.0	186.0	133.0	169.0
Total	1,109.0	820.0	785.0	1,038.0	954.0	1,057.0
Equivalent in quarts	47.2	34.9	31.3	44.2	40.6	45.0
Totals in quarts for 1898	29.7	22.9	26.4	37.5	21.8	24.8
Totals in quarts for 1899	56.3	47.5	74.6	70.6	59.5	66.2
Totals in quarts for 1900	168.7	98.2	125.0	161.9	128.4	134.5
The four years' totals combined	321.9	203.5	257.3	314.2	254.3	270.5

Currants.—Red Dutch has been the most productive variety upon each of the plots, and Victoria second. The yields per acre are as follows:

Fay's Prolific	5,049.09 quarts	Victoria	8,456.20 quarts.
Red Dutch	9,741.69 "	White Grape...	5,176.56 "

Considered by plots, we have:

a. Irrigation has given an increase on two of the three plots. Combining the yields in each case, the increase due to irrigation equals a little over 8 per cent.

b. Plots 1 and 4, receiving yard manure, have given the largest yields, plots 3 and 6 next, with 2 and 5 lowest.

c. Nitrate of soda, on plots 3 and 6, are second in yield this year. In previous years, these plots have given the lowest yields, excepting where unirrigated (plot 3), in 1898 it was second, and in 1899 first in yield. Combining the four seasons' yields, the irrigated plots have given yields a little over 15 per cent. larger than given when not irrigated. Plots 1 and 4, 3 and 5, 2 and 6, is the order of productiveness of the plots. The nitrated plots are second when not irrigated, and lowest where irrigation is practiced.

Gooseberries. The extremely hot weather of the last of June and first of July injured this fruit very materially, a greater part dropping to the ground. Because of the experiment, these were picked up as carefully as possible and weighed separately. The records show that 70.48 per cent. of the crop was thus injured. It is interesting to note that while the injury was great on all plots, it was not as severe where irrigated. When picked, there was on the bushes of the unirrigated plots, 23.3 quarts, and on those irrigated, 48.4 quarts. Houghton seemed to withstand the effects of the heat better than any of the other varieties, particularly where irrigated. Commercially, however, irrigation will not save a crop when we have temperatures of 100 to 103 degrees.

Considering the plots, we find that:

a. Irrigation has increased the yields in two of the three plots.

b. Yard manure, plot 1 of the unirrigated plots, and plot 6, chemical fertilizers, give the largest yields.

c. Nitrate of soda added gives the lowest results where not irrigated, and highest where irrigated.

Combining the four crops, the increase due to irrigation equals a little over 7 per cent. An increase, however, occurs on two plots

only ; plot 1, yard manure, unirrigated, exceeds plot 3, the irrigated duplicate. Yard manure has given the largest yields ; with those plots receiving nitrate of soda in addition to the bone, potash and acid phosphate mixture secoud, both were irrigated and not irrigated.

STRAWBERRIES—FERTILIZER PLOTS.

The plants in the fertilizer plots were set the last of August, 1899 ; fruit was produced in 1900 only on the original plants set. During the season of 1900, good matted rows were formed in every case. Fertilizers, as outlined, were applied April 30th, and on June 4th, nitrate of soda applied to plots 2, 3, 6 and 7. The irrigated plots received water four times, giving at each application the equivalent of a rainfall of .50, .75, .75 and 1.00 inch.

Table 9 contains the results for the year. The previous records of the fertilizer work with strawberries is also included, and covers the crops of 1897, 1898 and 1900.

TABLE 9.

Strawberry—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz	oz	oz.	oz.	oz.	oz.	oz.
Sharpless	June 13.	92.5	326.0	112.0	818.0	71.0	284.0	85.0	241.0
Bubach	" 8.	100.5	517.0	121.0	500.0	103.0	706.0	48.0	570.0
Downing	" 8.	54.0	821.0	55.0	404.0	24.5	288.0	84.5	408.0
Glen Mary	" 11.	107.5	614.0	97.0	644.0	62.5	584.0	86.0	640.0
Gandy	" 17.	92.5	352.0	86.0	331.0	39.0	277.0	57.0	293.0
Marshall	" 11.	67.5	318.0	77.5	347.0	78.0	850.0	83.5	881.0
Total		514.5	2443.0	546.5	2544.0	378.0	2384.0	344.0	2533.0
Equivalent in quarts		27.1	128.6	28.9	133.9	19.9	125.5	18.1	133.3
Totals in quarts for 1897		16.4	86.2	14.5	91.2	12.1	81.0	12.8	78.6
Totals in quarts for 1898		26.0	64.7	24.9	58.5	20.2	42.4	17.0	36.3
Totals in quarts for 1900		7.5	25.5	8.9	26.9	6.6	17.1	5.0	15.0
The four years' totals combined		77.0	305.0	77.2	310.5	58.8	266.0	52.4	263.2

Strawberry—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Sharpless	June 13.	56.0	177.0	69.5	201.0	63.5	214.0	44.0	126.0
Bubach	" 8.	80.5	508.0	153.5	517.0	85.5	338.0	118.0	577.0
Downing	" 8.	41.0	243.0	44.0	190.0	46.5	228.0	36.5	363.0
Glen Mary	" 11.	83.0	508.0	142.5	767.0	70.5	575.0	91.0	622.0
Gandy	" 17.	66.0	360.0	83.5	365.0	57.0	293.0	62.0	358.0
Marshall	" 11.	35.5	210.0	53.5	251.0	40.0	159.0	64.0	349.0
Total		362.0	2006.0	546.5	2291.0	363.0	1802.0	410.5	2395.0
Equivalent in quarts		19.1	105.6	28.8	120.6	19.1	94.8	21.6	126.1
Totals in quarts for 1897		16.8	76.8	12.8	56.1	16.1	82.8	17.8	87.9
Totals in quarts for 1898		27.6	61.5	25.0	62.6	25.4	49.2	20.7	40.3
Totals in quarts for 1900		5.6	19.1	7.6	20.3	7.7	20.4	6.4	17.4
The four years' totals combined		69.1	263.0	74.2	259.6	68.3	247.2	66.5	271.7

Of the varieties, Bubach gives the largest early yield on five and Glen Mary on three plots. In total yields, Glen Mary leads on six plots, Bubach on one, and they are the same in the eighth case. Yields per acre for these varieties are as follows :

	Early Yield.	Total Yield.
Sharpless	973.29 quarts.	3,290.12 quarts.
Bubach	1,441.89 "	7,572.92 "
Downing	601.67 "	4,370.26 "
Glen Mary	1,325.51 "	8,783.74 "
Gandy	972.61 "	4,708.87 "
Marshall	894.67 "	4,226.99 "

Grouping the varieties by plots :

a. The unirrigated plots lead in yield in all cases, excepting early yield on plot 4, which is exceeded by its irrigated duplicate.

b. Plots 2 and 6 give the largest early yields, with 1 and 8 second. In total yields, plots 2 and 8 are the largest, with 4 and 6 second.

c. When nitrate of soda is added to the complete fertilizer, plots 2 and 6, an increase in yield results ; when added to the mixture of bone, potash and acid phosphate, plots 3 and 7, an increase occurs only in early yield on the unirrigated plots.

Combining the four crops, irrigation has given a small increase in early yield only. The complete fertilizer with nitrate added has given the best results in early yields, and in totals on the unirrigated plots. Bone, potash and acid phosphate alone gave the largest yields under irrigation.

STRAWBERRIES—VARIETIES.

The variety test of last year was continued, and the plants fruited for the second time this season. After fruiting last year, the bed was cleaned, mulched in due time, and early the past spring a good application of a complete fertilizer given the bed. The bed was also irrigated twice, giving each time the equivalent of an inch of rainfall. The records were made as last year, and are given in table 10. Many of the plants set as hills failed to live for the second year's fruiting. The number living in each case is indicated in the third column of table.

Comparing *hills versus matted rows*, using as the basis the *yields per acre*, there are nineteen varieties that this year have given greater *returns from* hills than *from matted rows, as against* eleven in 1900. These are given below, with the yields over and above that given on the matted rows :

Hall's Favorite...	4,553 5 quarts.	Saunders	1,305.5 quarts.
*Warfield............	3,263.5 "	*Ridgeway..........	1,114.5 "
*Johnson's Early...	2,515.5 "	Michel's Early....	1,089.0 "
*Lady Thompson...	2,213.5 "	Glen Mary.........	1,067.0 "
*Parker Earle	2,213.0 "	*Wm. Belt..........	1,067.0 "
Jerry Rusk	2,085.5 "	Tennessee	1,050.5 "
Enhance............	1,926.5 "	Margaret...	589 5 "
*Hunn	1,719.0 "	Gandy	589.0 "
Seaford..	1,656.0 "	Ocean City....	111.5 "
Nick Ohmer.......	1,337.5 "		

The variety, Jerry Rusk, should hardly be included as above, since a considerable part of the matted row had failed. Ideal, Excelsior and Bubach are very nearly equal in yields obtained from the hills and matted rows. Starr gives upon the matted rows nearly double, and *Bismark* and Gladstone *more than twice that obtained* from hills. Bismark did the same last year. Without question, some *varieties* are better *adapted to* hill culture *than* others, and of those varieties given above as yielding better under hill culture, those that have given the same results for the two years may be regarded as the most desirable varieties for growing in hills.

* Exceeded the matted rows in 1900.

TABLE 10.

Strawberries—Varieties.

VARIETY.	Perfect or imperfect flowers.	HILLS, TWENTY-FOUR SQUARE FEET TO EACH VARIETY.					
		Date first picking.	Number plants fruited.	Yield before June 12.	Total yield.	Yield after June 25.	Total yield per acre in quarts.
				oz.	oz.	oz.	qts.
Bederwood	Per.	June 11.	17	6.0	38.0	2.0	3,630.0
Bismark	"	" 11.	7	12.5	27.0	....	2,579.0
Bubach'	Imp.	" 8.	8	9.0	90.0	14.5	8,597.5
Corsican	Per.	" 11.	9	5.0	67.0	12.0	6,400.5
Carrie	Imp.	....	....	....	....	....	....
Clyde	Per.	" 13.	14	....	7.0	0.5	668.5
Cobden Queen	Imp.	" 11.	11	4.0	83.5	1.5	3,200.0
Darling	Per.	" 8.	14	21.0	63.5	1.0	6,066.0
Enhance	"	" 13.	16	0.5	62.5	14.5	5,970.5
Enormous	Imp.	" 11.	8	4.5	43.0	1.0	4,107.5
Excelsior	"	" 8.	13	29.5	63.0	1.5	6,018.0
Gandy	"	" 17.	16	....	27.0	7.5	2,579.0
Gladstone	"	" 19.	4	....	16.0	4.5	1,528.5
Glen Mary	"	" 11.	15	1.0	81.5	6.5	7,785.5
Hall's Favorite	"	" 11.	14	14.0	80.5	4.0	7,690.0
Hunn	"	" 19.	14	....	49.5	22.5	4,728.0
Ideal	Per.	" 8.	16	4.0	97.0	8.5	9,266.0
Jerry Rusk	"	" 11.	2	....	31.5	....	3,009.0
Johnson's Early	"	" 8.	17	8.0	48.5	4.5	4.633.0
Lady Thompson	"	" 11.	15	6.0	38.5	3.0	3,678.0
Manwell	"	....	....	....	....	....	....
Margaret	"	" 11.	17	4.5	117.0	17.0	11,176.5
Michel's Early	"	" 8.	14	7.0	29.0	1.5	2,770.5
Nick Ohmer	"	" 11.	18	1.5	50.5	7.5	4,824.0
Ocean City	Imp.	" 13.	6	....	22.5	....	2,149.5
Parker Earle	"	" 13.	15	....	48.5	7.0	4,633.0
Pride of Cumberland	"	" 11.	17	4.5	43.0	5.0	4,107.5
Ridgeway	"	" 11.	18	0.5	56.0	13.5	5,349.5
Sample	"	" 11.	18	2.5	52.5	6.5	5,015.0
Saunders	Per.	" 11.	3	6.0	33.0	....	3,152.5
Seaford	Imp.	" 11.	18	1.5	74.0	9.0	7,069.0
Starr	Per.	" 11.	15	0.5	36.5	8.0	3,486.5
Tennessee	"	" 13.	17	....	65.0	11.0	6,209.0
Warfield	Imp.	" 11.	18	4.0	56.5	4.0	5,397.0
Wm. Belt	Per.	" 13.	17	....	59.5	9.5	5,684.0

TABLE 10—Continued.

Strawberries—Varieties.

VARIETY.	Perfect and imperfect flowers.	MATTED ROWS, SEVENTY-TWO SQUARE FEET TO EACH VARIETY.					
		Date first picking.	Yield before June 12.	Total yield.	Yield after June 25.	Total yield per acre in quarts.	Runner production, 10=max'm.
			oz.	oz.	oz.	qts.	
Bederwood	Per.	June 11.	4.0	180.5	16.5	5,747.5	9.5
Bismark	"	" 13.	....	206.0	9.0	6,559.5	9.5
Bubach	Imp.	" 11.	6.5	274.0	27.5	8,724.5	8.0
Corsican	Per.	....	....	....	....	....	....
Carrie	Imp.	" 11.	2.0	71.0	8.0	2,261.0	8.0
Clyde	Per.	" 11.	3.5	84.5	5.0	2,690.5	7.0
Cobden Queen	Imp.	" 11.	6.0	143.5	7.0	4,569.5	10.0
Darling	Per.	" 8.	28.5	234.5	10.5	7,467.0	8.5
Enhance	"	" 11.	2.0	127.0	33.5	4,044.0	9.0
Enormous	Imp.	" 11.	4.0	157.5	18.0	5,015.0	5.0
Excelsior	"	" 8.	83.0	198.0	6.0	6,304.5	8.5
Gandy	"	" 15.	....	62.5	25.0	1,990.0	7.0
Gladstone	"	" 13.	....	110.0	40.0	3,502.5	8.0
Glen Mary	"	" 11.	2.0	211.0	24.5	6,718.5	8.5
Hall's Favorite	"	" 11.	14.0	98.5	9.0	3,136.5	7.0
Hunn	"	" 11.	8.0	94.5	33.0	3,009.0	5.0
Ideal	"	" 8.	2.5	303.0	35.0	9,648.0	8.0
Jerry Rusk	"	" 11.	4.0	29.0	1.0	923.5	8.0
Johnson's Early	"	" 8.	1.0	66.5	10.0	2,117.5	10.0
Lady Thompson	"	" 11.	4.0	46.0	8.0	1,464.5	8.0
Manwell	"	" 11.	7.0	58.5	3.0	1,863.0	9.5
Margaret	"	" 11.	5.5	332.5	33.0	10,587.0	6.0
Michel's Early	"	" 8.	16.5	52.5	1.0	1,671.5	9.0
Nick Ohmer	"	" 11.	11.0	109.5	11.0	3,486.5	4.0
Ocean City	"	" 18.	....	64.0	7.5	2,038.0	7.5
Parker Earle	Per.	" 11.	0.5	76.0	13.5	2,420.0	8.0
Pride of Cumberland	"	" 11.	5.0	187.0	20.5	5,954.5	5.0
Ridgeway	"	" 11.	0.5	133.0	40.5	4,235.0	8.0
Sample	Imp.	" 11.	8.0	262.5	43.0	8,358.5	10.0
Saunders	Per.	" 11.	8.0	58.0	2.5	1,847.0	7.5
Seaford	Imp.	" 11.	1.0	170.0	14.5	5,413.0	8.0
Starr	Per.	" 13.	4.5	194.0	30.0	6,177.5	6.0
Tennessee	"	" 13.	....	162.0	19.5	5,158.5	10.0
Warfield	Imp.	" 11.	1.5	67.0	6.0	2,133.5	10.0
Wm. Belt	Per.	" 11.	2.0	145.0	22.0	4,617.0	9.5

Of the early sorts, Excelsior is by far the most productive this year, with Darling second.

In the late varieties, Sample leads in yield, after June 25th, as it did in 1900. Ridgeway and Gladstone are next in yield.

The half dozen most productive varieties grown as hills and as matted rows, are:

Hills.	Matted Rows.
*Margaret,	Margaret,
Ideal	Ideal,
Bubach,	*Bubach,
Glen Mary,	*Sample,
Halls Favorite,	Darling,
Seafard,	Glen Mary,
*Corsican,	*Bismark,
Darling,	Excelsior.

Margaret and Corsican (Big Berry) are the only ones of the hills, and Bubach, Sample and Bismark of the matted row lots that were included in the eight best in 1900.

THE THREE FRUITS.

The general plan is repeated, *i. e.*, the plots extend crosswise the rows, so that each plot includes two trees of each row; each row being a different variety. A cross-line of trees is set between the plots to prevent interfeeding by roots of trees extending into adjacent plots, and to test some of the newer varieties of the different tree fruits. Thus arranged, trees 1, 2, 4, 5, 7, 8, 10 and 11 of each row are included in plot work, while 3, 6, 9, etc., are the newer varieties. Table 11 shows detailed plan of fertilizers, amounts and times of application.

* In the similar list for 1900.

TABLE 11.

Showing Fertilizer, Amounts and Time of Application for the Various Fruit Trees.

KIND OF FRUIT.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Apples	Nothing.	500 lbs.‖ B. P. & A. P.† applied in spring.	500 lbs. B. P. & A. P. applied in spring.	
Peaches	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	500 lbs. P. & A. P.‡ applied in spring; 150 lbs. nitrate soda applied early and turned under.
Standard Pears	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring. 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 4.*	Plots 2 and 5.	Plots 3 and 6.	
Dwarf Pears	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 3.*	Plots 2 and 4.		
Plums, Cherries	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring. 150 lbs nitrate soda applied early and turned under.		

‖ The quantities of fertilizers given are in all cases the amount per acre to be applied.

† An even mixture of ground bone, muriate of potash and acid phosphate.

‡ A mixture of muriate of potash and acid phosphate in the proportion of 1 lb. of the former to 2 lbs. of the latter.

* Plots 1, 2 and 3, Dwarf Pears, and 1 and 2, Plums and Cherries, are irrigated as occasion demands.

The orchards were trimmed during March. Nitrate of soda was applied as per scheme May 14th and 15th, and the ground plowed. June 6th the general application of fertilizers was made and harrowed in. Those plots to be irrigated, *i. e.*, plots 1 and 2, plums and cherries, and 1, 2 and 3, dwarf pears, received June 29th, water equal to one and one-half inches of rainfall.

PLUMS AND CHERRIES.

Of the plums, Newman of the varieties in plots and Burbank and Satsuma Blood of the newer sorts, are the only ones fruiting this season. Early Richmond of the cherries gave a fair crop; the other two varieties in plots yielding but little fruit. Of the varieties, English Morello and Montmorency Ordinaire gave fair crops, with four others yielding a small quantity. Tables 12 and 13 contain the records for the year, together with totals of all previous crops.

TABLE 12.

Plums and Cherries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.				UNIRRIGATED.			
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		TREE 1.	TREE 2.	TREE 1.	TREE 2.	TREE 1.	TREE 2.	TREE 1.	TREE 2.
		Total yield.	Total yield.	Total yield.	Total yield.	Total yield.	Total yield.	Total yield.	Total yield.
Plums.		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz	lbs. oz.	lbs. oz.	lbs. oz.
Newman	Aug. 3-29.	3— 6	2— 2	3—14	10— 6	6— 6	9— 6	0—15	1— 7
Totals for 1899*	....	3— 6	22— 1	11— 5	22— 1	40—11	5—12	3— 5	2— 4
Totals for 1900†	....	41— 6	71— 7	42— 9	129—10	146— 4	36— 8	20— 3	15— 8
Totals for plots combined	....	143—12	....	219—13	....	244—15	....	48— 5	....
Cherries.									
Large Montmorency	July 13.	0— 4	....	0— 1	0— 2	0— 1	0— 1	0— 8	....
Louis Philippe	" 5.	0— 5	0—13	0— 4	0— 1	0— 1	0— 1	0— 2	....
Early Richmond	June 27.	0— 9	7—14	8— 7	10—10	4— 0	8—10	3— 9	4—14
Total	....	1— 2	8—11	8—12	10—13	4— 2	8—12	4— 3	4—14
Totals for 1899‡	....	0— 1	0— 3	0— 1	0— 7	0— 5	0— 5	0— 2	0— 4
Totals for 1900§	....	1— 1	8— 1	3— 2	6—10	7—15	9—12	4— 1	4— 2
Totals for plots combined	....	20— 3	....	24—13	....	31— 3	....	17—10	....

* Two varieties fruiting.
† Four varieties fruiting.
‡ One variety fruiting.
§ Three varieties fruiting.

TABLE 13.

Plums and Cherries—Varieties.

VARIETY—PLUMS.	Date first picking.	TREE 1. Total yield.	TREE 2. Total yield.	VARIETY—CHERRIES.	Date first picking.	TREE 1. Total yield.	TREE 2. Total yield.
		No. fts. oz.	No. fts. oz.			lbs. oz.	lbs. oz.
Burbank	Aug. 16.	7 11	25 39	Ostheim	July 5.	1—15	0—6
Satsuma Blood	" 16.	5 5	13 13	Royal Duke	" 5.	0— 3	0—4
				English Morello	" 13.	6— 3	4—5
				Montmorency Ordinaire	" 5.	9— 0	16—1
				Reine Hortense	" 5.	0— 6	0—3
				May Duke	" 5.	0— 4	0—3

These experiments have not been continued long enough to warrant any definite conclusions. However, considering the totals up to the present, as combined for each plot, plot 3 in each case has given the largest yield. Where irrigated, nitrate of soda added has resulted in increased yields, while upon the unirrigated plots that one receiving the additional nitrate has given the lowest yields throughout. In each fruit, one of the irrigated plots exceeds, and the other is less than its unirrigated duplicate. Combining the two plots in each case, the irrigated plots of the plums and unirrigated plots of the cherries have given the largest yields.

Of the varieties, the Burbank plum set a good quantity of fruit. A wind-storm first, and the brown rot later took the crop. The cherry Montmorency Ordinaire seems to be a desirable variety of this class of fruits.

DWARF PEARS.

The records of the fertilizer plots and of the varieties are given in Tables 14 and 15 respectively.

TABLE 14.

Dwarf Pears—Fertilizer Plots.

VARIETY.	IRRIGATED.											
	PLOT 1.				PLOT 2.				PLOT 3.			
	TREE 1.		TREE 2.		TREE 1.		TREE 2.		TREE 1.		TREE 2.	
	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.
Dwarfs proper.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
Lawrence	14	3— 4	....	....	.....	....	1	0— 4	2	0—7	.....	....
Bartlett	.....	....	.....	....	13	2 —9	4	1— 1	9	2—7	6	1— 7
Dwarfs by cutting.												
Lawrence	.....	....	2	0—10	.....	....	.....	....	6	2—7	.....	....
Bartlett	.....	....	4	0—14	.....	....	.....	....	.....	....	13	2—12
Keiffer	47	14— 4	2	0—10	14	4—12	7	2— 7	22	8—4	9	3—13
Total	61	17— 8	8	2— 2	27	7— 5	12	3—12	39	13—9	28	8— 0
Totals for 1900	31	9—14	.....	....	43	18— 4	125	36— 6	43	12—2	41	12—13

Dwarf Pears—Fertilizer Plots.

VARIETY.	UNIRRIGATED.											
	PLOT 4.				PLOT 5.				PLOT 6.			
	TREE 1.		TREE 2.		TREE 1.		TREE 2.		TREE 1.		TREE 2.	
	No. fruits.	Weight.	No fruits.	Weight.	No. fruits.	Weight	No fruits	Weight.	No. fruits	Weight.	No. fruits.	Weight.
Dwarfs proper.		lbs. oz		lbs. oz		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.
Lawrence	1	0— 4	....	....	.....	....	1	0— 4	.....	....	.....	....
Bartlett	1	0— 6	.....	....	19	5— 0	11	3— 8	2	0— 7	.....	....
Dwarfs by cutting.												
Lawrence	....	....	....	....	.....	....	.....	....	....	....	.....	....
Bartlett	4	0—15	.....	....	.....	....	.....	....	1	0— 5	.....	....
Keiffer	84	12— 3	16	4—3	7	2—11	15	5—13	19	6—10	.....	....
Total	40	13—12	16	4—8	26	7—11	27	9— 9	22	7— 6	.....	....
Totals for 1900	82	25—14	50	18—9	6	2— 0	103	26—12	16	3—12	.....	....

TABLE 15.

Dwarf Pears—Varieties.

VARIETY.	TREE 1.		TREE 2.	
	No. fruits.	Weight.	No. fruits.	Weight.
Dwarfs proper.		lbs. oz.		lbs. oz.
Margaret	....	....	1	0— 5
Angouleme	4	2— 9	2	1—12
White Doyenne	1	0— 5	3	0—12
Seckel	4	0— 9	....	....
Dwarfs by cutting.				
Le Conte	24	8—13	22	7—14
Clairgeau	....	....	4	1—15

The data at hand is insufficient to permit any definite conclusions, a full crop not being as yet given by any of the varieties. In the yield of 1900, the average weight per fruit was for the irrigated plots 4.77, and for those not irrigated, 4.48 ounces. This season the fruit from the unirrigated plots averages the heaviest, or 5.24, as against 4.78 ounces, for those irrigated. The irrigated plots exceed in yield, in two cases, the unirrigated plots, and combined, the irrigated plots exceed in yield the unirrigated by a little over 19 per cent. The blank plots, with one exception, have given larger yields than those receiving fertilizers.

STANDARD PEARS.

Tables 16 and 17 contain the data of the year's yield, together with that of 1900, and are presented as a matter for record. It may be noticed that plot 1, blank, has so far given the largest yield, thus emphasizing a point frequently made that young trees on good soils, and where no other crop is grown, do not need applications of fertilizer. Later, as the trees begin to bear more heavily, fertilizers may be added advantageously.

TABLE 16.

Standard Pears—Fertilizer Plots.

VARIETY.	PLOT 1.				PLOT 2.				PLOT 3.			
	TREE 1.		TREE 2.		TREE 1.		TREE 2.		TREE 1.		TREE 2.	
	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.	No. fruits.	Weight.
		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz.		lbs. oz
Lawrence	.....	....	1	0— 6	.....	....	.....	....	1	0— 4	.....	....
Bartlett	.....	....	.....	....	80	7— 0	1	0— 4	2	0— 9	28	5—14
Keiffer	73	27—7	156	56—14	86	32—12	62	22— 8	130	48—10	87	34—11
Total	73	27—7	157	57— 4	116	37—12	63	22—12	133	49— 7	110	40— 9
Totals of 1900	69	22—0	94	29— 6	9	2—14	149	49— 0	54	17— 0	67	21—10

TABLE 17.

Standard Pears—Varieties.

VARIETY.	TREE 1.		TREE 2.	
	No fruits.	Weight.	No. fruits.	Weight.
		lbs. oz.		lbs. oz.
Koonce	....	....	10	2— 6
P. Barry	....	....	12	4— 7
Dorset	4	1— 3	10	2—11
Angel	1	0— 7	1	0— 7
Winter Nelis	19	8—15	2	0— 8
Keiffer (Stringfellow)	....	....	17	6— 1

PEACHES—FERTILIZER PLOTS.

The general treatment of the orchard has already been outlined. The detailed records of the year, together with the totals of the two previous crops, are presented in Table 18. In the last column of the records for each tree, there is given the number of fruits removed

TABLE 10.

Peaches.—Fertilizer Plots.

VARIETY.	PLOT 1.																			
	TREE 1.										TREE 2.									
	Date first picking.	TOTAL YIELD.						Average size Nos. 1 and 2, respectively.		No. removed in thinning.	Date first picking.	TOTAL YIELD.						Average size Nos. 1 and 2, respectively.		No. removed in thinning.
		No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.					No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.			
			lbs. oz.		lbs. oz.		lbs. oz.	oz.					lbs. oz.		lbs oz.		lbs. oz.	oz.		
Susquehanna	Sept. 9.	67	17—12	24	3—14	8	0—12	4.2	2.6	340	Sept. 9.	62	14—1	49	7—14	47	2—11	3.6	2.6	550
Stevens' Rareripe	" 28.	10	1—11	321	37—11	66	4—15	2.7	1.9	446	" 28.	4	0—10	193	20—0	44	3—0	2.5	1.7	283
Elberta	" 7.	328	77—13	83	18—14	20	2—5	3.8	2.7	496	" 9.	299	57—5	300	42—4	47	4—12	3.1	2.8	547
Crawford's Late	" 16.	54	10—4	52	7—4	14	1—8	3.0	2.2	8	" 16.	144	25—11	117	15—13	81	2—10	2.9	2.2	55
Reeves' Favorite	" 5.	117	26—0	39	5—15	5	0—9	3.6	2.4	157	....	....	....	....	....	....	....	....	....	....
Old Mixon	" 9.	220	43—8	281	39—2	43	3—14	3.2	2.2	541	" 9.	24	3—15	434	50—10	81	6—5	2.5	1.9	366
Total	....	796	176—11	800	107—12	156	13—15	3.6	2.2	1,988	....	*654	126—13	1,265	158—12	287	22—6	3.1	2.0	2,145
Total for 1899	....	169	40—8	169	24—11	33	3—8	....	....	35	....	165	52—10	397	70—13	91	10—1	....	....	177
Total for 1900	....	1,407	229—7	1,414	189—15	276	18—1	....	....	842	....	1,315	185—8	3,173	249—9	726	35—6	....	....	1,099
Total, excluding Stevens' Rareripe	....	786	175—0	479	70—1	90	9—0	3.6	2.3	1,542	....	*649	125—15	1,025	138—8	233	18—11	3.1	2.1	1,796
Total for 1899	....	109	26—9	66	10—11	13	1—6	....	....	....	....	140	40—2	237	46—5	54	6—8	....	....	108
Total for 1900	....	856	184—7	522	78—14	98	9—8	....	....	377	....	1,228	154—1	2,088	178—1	478	25—0	....	....	672

* Calculated for full plot, 1 tree out.

TABLE 18—Continued.

Peaches.—Fertilizer Plots.

VARIETY.	PLOT 2.																			
	TREE 1.										TREE 2.									
		TOTAL YIELD.										TOTAL YIELD.								
	Date first picking.	No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.	Average size Nos. 1 and 2, respectively.		No. removed in thinning.	Date first picking.	No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.	Average size Nos. 1 and 2, respectively.		No. removed in thinning.
			lbs. oz.		lbs. oz.		lbs. oz.	oz.					lbs. oz.		lbs. oz.		lbs. oz.	oz.		
Susquehanna	Sept. 9.	59	11—12	118	16— 6	42	2— 9	3.2	2.2	450	Sept. 8.	15	3— 5	16	2— 4	21	1—15	3.5	2.3	108
Stevens' Rareripe	" 28.	....	....	46	3—11	18	0—14	.....	1.3	15	" 28.	37	5—15	269	30— 4	29	2— 1	2.6	1.8	410
Elberta	" 9.	140	26— 5	136	19— 1	20	2— 3	3.0	2.2	198	" 9.	103	16— 5	203	27— 6	19	1—15	2.8	2.2	421
Crawford's Late	" 16.	128	22—11	149	19—12	18	1—15	3.0	2.1	67	" 16.	49	8—15	90	12—10	13	1— 9	2.9	2.2	19
Reeves' Favorite	" 3.	28	3—10	42	6—14	8	0— 6	2.5	2.2	9	" 5.	109	23— 5	36	5— 8	6	0—10	3.4	2.4	72
Old Mixon	" 9.	257	47—11	156	20—15	26	2— 7	3.0	2.1	687	" 9.	258	40—11	426	53—14	82	6—14	2.5	2.0	650
Total	....	602	112— 1	647	85—11	122	10— 6	3.0	2.1	1,376	....	571	100— 8	1,040	131—14	170	15— 0	2.8	2.0	1,680
Total for 1899	....	267	67—10	287	51—12	54	6— 4	....	....	97	....	213	64— 1	388	71— 0	63	8— 1	....	....	284
Total for 1900	....	1,756	191— 6	1,887	146— 5	356	17—11	...	....	926	....	1,204	168— 1	2,192	220— 8	358	25— 1	....	....	1,003
Total, excluding Stevens' Rareripe	....	602	112— 1	601	82— 0	109	9— 8	3.0	2.0	1,361	....	534	94— 9	771	101—10	141	12—15	2.8	2.1	1,270
Total for 1899	....	216	57— 6	216	41—15	39	4—14	....	....	64	....	159	41— 1	229	44— 2	42	5—10	....	....	130
Total for 1900	....	1,220	151— 5	1,218	110—11	221	12—13	....	....	673	....	977	138—12	1,410	149— 1	258	19— 0	....	....	627

TABLE 18—Continued.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 3.																			
	TREE 1.										TREE 2.									
		TOTAL YIELD.										TOTAL YIELD.								
	Date first picking.	No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.	Average size Nos. 1 and 2, respectively.		No. removed in thinning.	Date first picking.	No. 1 fruits.	Weight.	No. 2 fruits.	Weight.	Culls, No.	Weight.	Average size Nos. 1 and 2, respectively.		No. removed in thinning.
			lbs. oz		lbs. oz.		lbs. oz.	oz.					lbs. oz.		lbs. oz.		lbs. oz.	oz.		
Susquehanna	Sept. 13.	25	6—12	3	0— 8	.....	....	4.3	2.7	39	Sept. 9.	27	6— 7	19	2—14	9	1— 0	3.8	2.4	58
Stevens' Rareripe	" 28.	69	12— 3	364	44— 8	41	3— 1	2.8	1.9	684	" 28.	81	14— 4	460	56—10	56	3—13	2.7	2.0	744
Alberta	" 9.	209	46—13	88	13—11	12	1— 7	3.6	2.5	702	" 7.	290	58— 9	186	26— 9	56	5— 4	3.2	2.8	757
Crawford's Late	" 8.	82	15—15	185	23—15	84	6— 8	3.1	2.1	125	" 9.	32	5— 8	170	20— 8	78	5—10	2.6	1.9	21
Reeves' Favorite	" 5.	65	16— 4	15	2— 7	5	0—10	4.0	2.6	22	" 8.	100	26—12	30	4—12	11	1— 2	4.1	2.6	81
Old Mixon	" 9.	410	56—15	419	54— 6	60	5— 0	2.2	2.1	689	" 9.	159	28—11	397	50— 6	90	7— 1	2.9	2.0	1,079
Total	....	860	154—14	1,074	139— 7	202	16— 5	2.9	2.1	2,261	....	692	138—14	1,262	161—11	299	23—14	3.2	2.0	2,684
Total for 1899	....	302	69— 5	376	62— 7	71	7— 5	.....	.....	249	....	173	47—13	315	55—11	75	3— 4	.....	....	207
Total for 1900	....	1,841	205— 0	1,675	184— 9	315	21—10	.....	.....	998	....	1,021	186— 5	1,862	216—15	441	32— 1	.....	......	1,055
Total, excluding Stevens' Rareripe	....	791	142—11	710	91—15	161	13— 4	2.9	2.1	1,577	....	608	124—10	802	105— 1	244	20— 1	3.3	2.1	1,940
Total for 1899	....	250	57— 1	224	33— 0	51	5— 5	.....	.....	157	....	136	37— 6	179	31— 8	55	6— 0	.....	......	155
Total for 1900	....	1,038	149— 6	927	99— 7	210	13—14	.....	.....	514	....	834	149—11	1,099	126— 8	334	21— 2	....	......	623

TABLE 18—Continued.

Peaches—Fertilizer Plots.

VARIETY.	PLOT 4. Tree 1. Date first picking.	Tree 1. Total yield. No. 1 fruits.	Tree 1. Total yield. Weight.	Tree 1. Total yield. No. 2 fruits.	Tree 1. Total yield. Weight.	Tree 1. Total yield. Culls, No.	Tree 1. Total yield. Weight	Tree 1. Average size Nos 1 and 2, respectively.		Tree 1. No. removed in thinning.	Tree 2. Date first picking.	Tree 2. Total yield. No. 1 fruits.	Tree 2. Total yield. Weight.	Tree 2. Total yield. No. 2 fruits.	Tree 2. Total yield. Weight.	Tree 2. Total yield. Culls, No.	Tree 2. Total yield. Weight.	Tree 2. Average size Nos. 1 and 2, respectively.		Tree 2. No. removed in thinning.
			lbs. oz.		lbs. oz.		lbs. oz.	oz.					lbs. oz.		lbs. oz.		lbs. oz.	oz.		
Susquehanna	Sept. 9.	27	6—13	5	0—12	2	0—3	4.0	2.4	61	Sept. 18.	2	0—7	2	0—5	.....	....	3.6	2.5	....
Stevens' Rareripe.....	....	....	....	....	....	....	....	......	......	....	....	....	....	....	....	.....	....	......	....	....
Elberta	" 7.	376	87—2	71	10—11	11	1—3	3.7	2.4	953	" 7.	266	58—2	96	14—10	14	1—8	3.5	2.4	430
Crawford's Late.......	" 16.	219	46—2	76	11—4	26	3—2	3.4	2.4	118	" 16.	160	36—9	46	6—10	12	1—8	3.7	2.3	211
Reeves' Favorite	" 5.	38	10—8	9	1—9	1	0—1	4.3	2.8	19	" 5.	51	13—14	8	1—7	1	0—2	4.4	2.9	30
Old Mixon..............	" 9.	205	39—1	278	37—2	73	6—4	3.0	2.1	429	" 9.	192	36—14	394	52—0	81	6—14	3.1	2.1	495
Total, excluding Stevens' Rareripe..............	....	865	189—5	489	61—6	112	10—13	3.5	2.2	1,580	....	671	145—14	546	75—0	108	10—0	3.5	2.2	1,165
Total for 1899......	....	179	46—1	91	14—15	28	2—10	......	......	60	....	196	52—13	159	27—3	31	8—10	......	......	101
Total for 1900......	....	1,180	198—1	574	64—4	146	11—5	......	......	539	....	921	180—15	750	93—1	148	12—6	......	......	566

in thinning, an operation quite thoroughly performed the last of June. The total yield this year was sorted into firsts, seconds and culls, and are thus given in the table. In order to present the totals of the two previous crops more easily, they were divided into firsts, seconds and culls, in the same ratio as was given this season. The first three plots only can be compared in using the first totals given. The second totals—excluding Stevens' Rareripe—are to be used in comparing all four plots.

A study of these detailed records reveals many interesting points in the variation of plant growth and productiveness. Thus, the average size of the fruit as sorted into firsts and seconds from trees of the different varieties, range and average as follows:

	Firsts.		Seconds.	
Susquehanna..........	3.2 oz. to 4.3 oz.	av. 3.76 oz.	2.2 oz. to 2.7 oz.	av. 2.46 oz.
Stevens' Rareripe...	2.5 " " 2.8 "	" 2.66 "	1.3 " " 2.0 "	" 1.77 "
Elberta..................	2.8 " " 3.8 "	" 3.34 "	2.2 " " 2.7 "	" 2.38 "
Crawford's Late......	2.6 " " 3.7 "	" 3.08 "	1.9 " " 2.4 "	" 2.18 "
Reeves' Favorite.....	2.5 " " 4.4 "	" 3.29 "	2.2 " " 2.9 "	" 2.24 "
Old Mixon............	2.2 " " 3.2 "	" 2.80 "	1.9 " " 2.2 "	" 2.06 "

Susquehanna gives the largest fruits, with Elberta second in size and Stevens' Rareripe smallest in average weight. The Elberta is one of the most productive sorts and quite uniform. On tree 1, plot 1, nearly 83 per cent. of the fruit by weight, sorted as No. 1, and on the first tree in plot 4, almost 88 per cent. graded first. In contrast to this, take the second tree in plot 2, which has only 38.4 per cent. firsts. Then in the total yields we have from one Elberta tree 99 pounds of fruit, and only 47 pounds 9 ounces from another. Similar differences are to be noted in all the varieties.

Grouping the varieties together, taking the totals of the six first trees, and the second six trees in each plot, we have the following percentages in each case of first and second-grade fruit:

	First Trees.		Second Trees.	
	Firsts. Per cent.	Seconds. Per cent.	Firsts. Per cent.	Seconds. Per cent.
Plot 1. Stevens' Rareripe, included........	59.2	36.1	41.2	51.7
" 2. " " "	53.8	41.2	40.6	53.3
" 3. " " "	49.8	44.9	42.8	49.8
" 1. " " excluded.......	68.9	27.6	44.3	48.0
" 2. " " "	55.1	40.3	45.2	48.6
" 3. " " "	56.9	37.8	49.9	42.1
" 4. " " "	72.4	23.5	63.2	32.5

In the first six trees of all the plots, 50 per cent. or more of the fruit grade as firsts. On the second six trees the greater part of the fruit grades as seconds. Only on plots 3 and 4, Stevens' Rareripe excluded, does the percentage of firsts exceed that of seconds, and in one plot only (plot 4) does the proportion of first-grade fruit exceed 50 per cent.

The results by plots are better understood by examining the following table, where the yields of the twelve trees of each plot are here combined. The records for the two previous crops are also included. The general results for 1901 are the same as the averages for the three crops, hence only the latter figures are considered :

TABLE 19.

Peaches—Totals of Fertilizer Plots.

	Stevens' Rareripe excluded					*Stevens' Rareripe included.*				
	Number fruits removed in thinning.	Number ripe fruits.	Weight ripe fruits.	Average weight per fruit.	Yield per acre, baskets.	Number fruits removed in thinning.	Number ripe fruits.	Weight ripe fruits.	Average weight per fruit.	Yield per acre, baskets.
			lbs. oz.	oz.				lbs. oz.	oz.	
Plot 1—1899	108	619	131— 9	3.40	76	212	1,024	201—14	3.15	116
1900	949	6,270	624—15	1.90	361	1,941	8,311	857—14	1.65	495
1901	[illegible],338	3 262	582— 3	2.61	307	4,133	3,958	606— 5	2.45	350
Average	1,465	3,050	429— 9	2.64	248	2,095	4,431	555— 6	2.42	320
Plot 2—1899	194	901	195— 0	3.46	113	331	1,272	258—12	3.25	149
1900	1,300	5,304	581—10	1.75	336	1,929	7,758	769— 0	1.59	444
1901	2,631	2,758	412—11	2.39	238	3,056	3,152	455— 8	2.31	263
Average	1,375	2,988	396— 7	2.58	229	1,772	4,059	494— 7	2.38	285
Plot 3—1899	312	895	175— 4	3.13	101	456	1,312	250—13	3.06	145
1900	1,[illegible]37	4,437	562—11	2.03	325	2,053	6,655	846— 8	2.04	488
1901	3,517	3,316	500—10	2.42	289	4,945	4,389	635— 1	2.32	366
Average	1,655	2,888	412—14	2.58	238	2,485	4,119	577— 7	2.47	333
Plot 4—1899	161	679	147— 4	3.47	85	....	....	....	.....	......
1900	1,095	3,669	560— 0	2.66	323	....	....	....	.....	......
1901	2,746	2,741	492— 6	2.88	284	....	....	....	.....	......
Average	1,334	2,363	399—14	3.00	231	....	....	....	.....	......

Taking first the three plots, with Stevens' Rareripe included, plot 3, with nitrate of soda added to the general fertilizer, has given the greatest weight of fruit, but the average size of the fruit is the least of the three plots. The blank plot (No. 1) is second in yield and first in average weight per fruit. Comparing the four plots, Stevens' Rareripe excluded, the blank plot has given the greatest yield, but the fruit from this plot is second in average size. Plot 3 gives the second largest yield, with plot 4 third. Plot 4 has, however, the largest average weight per fruit.

PEACHES—VARIETIES.

Butler's Late is the only sort this year failing completely. In table 20 is given the yields of the different varieties for the year, and in the last two colums the average of the three crops and the average weight per fruit for same.

TABLE 20.

Peaches—Varieties.

VARIETY.	Date first picking.	Tree 1. No. 1 fruits.	Tree 1. Weight.	Tree 1. No. 2 fruits.	Tree 1. Weight.	Tree 1. Culls, No.	Tree 1. Weight.	Tree 2. No. 1 fruits.	Tree 2. Weight.	Tree 2. No. 2 fruits.	Tree 2. Weight.	Tree 2. Culls, No.	Tree 2. Weight.	Average of three crops, '99, '00, '01. Total weight.	Average of three crops, '99, '00, '01. Average per fruit.
			lbs. oz.		lbs oz.		lbs. oz.		lbs oz		lbs. oz.		lbs oz	lbs. oz.	oz.
Triumph	Aug. 1.	48	8—10	140	14— 8	45	8— 5	70	18— 7	146	18— 8	8	0—12	58— 7	1.45
Wonderful	Sept. 28.	41	8— 0	79	10— 0	7	0—12	1	0— 8	57	6— 8	29	1—15	82—12	2.67
Ward's Late White	" 28.	7	1— 1	5	0—11	2	0— 2	103	18— 7	318	40— 1	22	1—12	139— 7	1.93
Champion	Aug. 28.	236	54— 1	151	23—13	22	1—15	195	40— 5	219	32—13	73	7— 2	178— 9	2.77
Butler's Late	....	....	....	....	....	....	....	....	....	....	....	....	....	*57— 5	1.82
Surpasse	Aug. 28.	102	22—15	105	15— 8	16	1— 9	80	16— 6	129	18— 2	35	2—15	†65— 9	2.67
Sneed	July 20.	....	....	199	21—11	....	....	....	....	146	18—12	....	....	†28— 9	1.68
Crosby	Sept. 9.	91	17— 4	184	18— 1	38	3—15	167	81— 0	297	40—11	67	6— 4	†27— 7	2.49

* One tree and two crops only. † Two crops only.

PEACHES.

a. The Stringfellow Method of Setting.
b. Severe *vs.* Moderate Thinning.

The details of this experiment, together with the yield in the first crop, were given in the report for 1900. The records for the year, together with the totals of 1900, are given in Table 21.

TABLE 21.

The Elbertha Peach—a. The Usual or Stringfellow Method of Setting Trees. b. Severe vs. Moderate Thinning.

	AS USUALLY SET.							STRINGFELLOW PLAN.			
	Number removed in thinning.	Calculated to leave on tree.	Number ripe fruits picked.	*Weight ripe fruit.*	Average size per fruit.	Per cent. sorting as No. 1 in weight.	Average size No. 1 fruits.	Number removed in thinning.	Number ripe fruits picked.	*Weight ripe fruits.*	Average size per fruit.
				lbs. oz.	oz		oz.			lbs. oz.	oz.
Tree 1	1,674	290	134	28— 9	3.41	74.84	3.72	435	52	10— 8	3.75
" 2	838	500	269	66— 1	3.33	72.58	3.90	664	388	73—11	3.04
" 3	744	700	357	60— 3	2.68	57.11	3.25	....	....	....	....
Total	3,256	....	760	144—13	....	....	....	1,099	440	83—14	....
Totals for 1900	1,087	....	1,376	267— 3	....	....	....	508	1,048	208—11	....

One tree set by Stringfellow's *method died during the summer.* Tree No. 1, Stringfellow's set, is small, and only tree No. 2 compares at all with those set as is usually done. The yield of this tree exceeds that of its duplicate as usually set, but the number removed in thinning was 664 as against 838. Taken as a whole, the Stringfellow trees have given yields much below that of those set as usual.

The *decisive results* attending severe *vs.* moderate thinning last season led to a continuance of this work this year. Column 2 of the table shows the number calculated to be left on each of the three trees set in usual manner, these being quite uniform in size and growth.

The extremely wet July and August caused many of the fruits, particularly on the tree most severely thinned, to crack badly and drop. In reality, we secured on trees 2 and 3 very nearly what we aimed at on 1 and 2. First, it is interesting to compare the total set of this year with the number left on the tree last year, as follows:

	Tree 1.	Tree 2.	Tree 3.
Removed in thinning, 1900...	599 fruits.	272 fruits.	216 fruits.
Picked ripe in 1900............	263 "	580 "	533 "
Total set, 1901..................	1,964 "	1,338 "	1,444 "

Comparing, as noted above, trees 2 and 3, No. 2 gave 56 pounds 1 ounce of fruit, of which 72.58 per cent., approximately 1.56 baskets, graded as number 1, with an average weight of 3.9 ounces. Tree No. 3 gave a total of 60 pounds 3 ounces, of which only 57.11 per cent., 1.32 baskets, graded as number 1, with an average weight of only 3.25 ounces. Taking the total yields of these trees, that of No. 2 averaged 3.33 ounces, and that of No. 3 only 2.68 ounces per fruit.

While the market value was not definitely determined, it is not difficult to judge as to which tree gave the most profit, particularly with only 4 pounds difference in total yields, but a difference in size of nearly two-thirds of an ounce per fruit.

BUSH FRUITS—NEW VARIETIES AND SUB-IRRIGATION.

When laying out the experimental work in the spring of 1896, a small plot of ground was set aside for the testing of a few of the newer sorts of the bush fruits, and also to study the effect of sub-irrigation for these fruits under field conditions. The fruits thus provided for have been pruned, fertilized and cultivated along with the various fruits in the permanent plots, though it is doubtful if the general conditions have been quite as favorable to plant growth as in the latter case. Records have been made each season of the yields, etc., of the different varieties as demanded, and the results are given to date in table 22. Yields are also included from similar areas of standard or similar varieties for comparison.

TABLE 22.

Novelties—Newer Varieties.

VARIETY.	Yield of 1898.	Yield of 1899.	Yield of 1900.	Yield of 1901.	The four years' totals combined.
	oz.	oz.	oz.	oz.	oz.
Columbian Raspberry	46.5	69.0	56.5	42.0	214.0
Loudon Raspberry	11.0	68.0	140.0	232.0	451.0
Miller Raspberry	63.5	98.0	118.0	151.0	430.5
Superlative Raspberry	31.0	....	....	18.0	49.0
Cuthbert Raspberry	82.0	215.0	171.5	119.5	588.0
Austin's Dewberry	25.5	....	86.0	83.0	194.5
Allen Blackberry	....	....	214.5	252.5	467.0
Early Harvest Blackberry	....	....	421.5	132.0	558.5
White Imperial Currant	9.5	50.5	108.0	44.5	212.5
White Grape Currant	9.5	56.5	64.0	196.5	326.5
Red Jacket Gooseberry	49.0	45.5	305.6	....	400.0
Downing Gooseberry	78.0	317.5	651.5	....	1,047.0

NOTES.

Columbian Raspberry.—A purple cap berry, hardy and vigorous. The small yield due to the fact of only two bushes fruiting. The only one of its class on the grounds. Pronounced by the Michigan Station to be the best of its kind.

Loudon.—A cross between the Turner and Cuthbert. Plants vigorous and hardy. Berry large and attractive. Not equal to Cuthbert in quality or productiveness. A little earlier than the latter in maturing.

Miller.—Ripens a very little latter than Marlboro. Berries not equal to Loudon in size, but a bright, attractive red. Plants vigorous and fairly productive.

Superlative.—The fruit is brigbt red and attractive, but plants are not hardy.

Austin's Dewberry.—Set spring of 1897. Gave a little fruit in 1898, failed in 1899, and in 1900 and 1901 gave a fair amount of fine fruit.

Allen Blackberry.—Set in spring of 1898. A seedling of Early Harvest and rather superior to it. The yields of Early Harvest in table are from plants four years' set.

White Imperial Currant.—An excellent white sort, fruit mild acid and good. Vigorous and quite productive. Not superior to White Grape.

Red Jacket Gooseberry.—A new sort of American origin. Resembles Downing. Larger, but not as productive. Fruit reddish green in color.

SUB-IRRIGATION FOR BUSH FRUITS.

In preparation for sub-watering, or irrigation, a deep furrow was turned in line of the row to be, and on the bottom of the furrow, two-inch round tile was laid, end to end. The last tile at the upper end came to the surface to admit water from a hose into the line of tile. Plants of three varieties of raspberries, four of currants and two of gooseberries were set in place as the furrow was filled in and the soil thoroughly firmed. The general care was the same as in the other fruits, with the addition of water into the tile under the row twice in 1896, three times in 1897 and 1898, once in 1899, none in 1900, and once in 1901. The amount of water given ranged from .75 inch to 3 inches, the average application being 1.46 inches. The results are given in table 23. The figures in the last column are added for comparison and are obtained by adding the yields of of the four unirrigated plots of the same varieties and reducing to equal areas.

TABLE 23.

Sub-Irrigation for Small Fruits.

VARIETY.	Yield of 1898.	Yield of 1899.	Yield of 1900.	Yield of 1901.	The four years' totals combined.	FOUR YEARS' TOTALS FROM EQUAL AREAS. Averaged from all the unirrigated plots.
	oz.	oz	oz.	oz.	oz.	
Fay's *Prolific* Currant	6.5	131.5	157.0	146.0	441 0	454.5
Red Dutch Currant	15.5	171.0	337.5	282.0	806.0	1,299.5
Victoria Currant	14.5	96.5	180.5	224.0	515.5	791.0
White Grape Currant	5.0	68.0	50.0	133.0	251.0	328.0
Downing Gooseberry	74.0	47.0	320.0	....	441.0	1,047.0
Triumph Gooseberry	44.0	173.5	320.0	....	537.5	372.5
Cuthbert Raspberry	33.5	121.0	184.0	176.5	515.0	588.0
Marlboro Raspberry	84.5	149.0	182.0	24.5	440.0	219.5
Turner Raspberry	28.5	26.5	140.0	200.0	395.0	497 0

The yields in two cases only (Triumph gooseberry and Marlboro raspberry) exceed in yield that obtained upon the unirrigated lots. The difficulties in keeping the line of tile open and free are too great to render the use of tile for sub-irrigation practicable. Mice and toads find the tile excellent shelter.

VEGETABLES.

Since reporting the tests of varieties of beans, peas and tomatoes in 1898, a few of the newer sorts of these vegetables offered by seedsmen have been grown each season, together with a few of the old standard sorts for comparison.

Climatic conditions were as follows for the four growing months :

	1899.	1900.	1901.
May	2.04	5.58	5.01
June	3.54	2.64	0.81
July	6.32	6.94	9.12
August	3.45	2.24	8.90
Average	3.84	4 35	5.96

The rainfall of 1899 and 1900 was fairly well distributed, but in 1901 the spring was cold and the month of June very dry.

BEANS—VARIETIES.

Fourteen varieties were grown and records made each year. Table 24 contains the average of these records, covering in all cases two and in several cases three seasons' work.

Fillbasket Wax (Thorburn) is the earliest maturing sort, with Bountiful and Stringless Green Pod second, early. Of the green sorts, Vienna Forcer has given the largest proportion of the total yield in the first picking. Second in this respect, and but little difference between them, are Bountiful, Stringless Green Pod and Giant Stringless Green Pod. Scarlet Wax and the old Improved Golden Wax give the greatest proportion of total yield in first picking of the wax sorts.

Jones' Stringless Wax is the the most productive sort. Scarlet Wax is second of the yellow-podded varieties. Of the green-podded sorts, Stringless Green Pod leads, with Giant Stringless and First in Market the same, and second in yield. Crystal White Wax is a desirable new variety. One of the most productive of rather short, roundish, thick, meaty pods, greenish white in color and stringless.

For three seasons, a comparison of the bush and pole lima beans has been made, using the Large White pole and Burpee's bush and Dreer's Improved pole and Dreer's bush limas. The seed was planted in proper season, in fairly rich soil and treated the same, except providing a trellis for the pole sorts, as follows: Two wires are stretched over the row, one near the ground and the other about four feet above the first. A loose hemp cord is stretched between these wires by passing over and under, thus forming a fair trellis, to which the pole sorts attach themselves.

Table 25 contains the averages of the three seasons' work.

TABLE 24.

Beans—Varieties.

VARIETY.	Seedsman.	Days to marketable maturity.	Amount first picking.	Total yield.	Yield per vine.	Weight per vine.	Length of pod.	Color.	Shape of pod.
			oz.	oz.	oz.	oz.	in.		
Bountiful	Henderson	56	17.0	36.5	.50	.67	5.0	Light green.	Flat, thick.
Everbearing	Burpee	64	8.7	24.0	.53	.73	4.5	Green.	Flat, thin.
Stringless Green Pod	Burpee	56	15.5	33.8	.79	.93	4.5	Light green.	Round.
Earliest Red Valentine	Henderson	57	12.0	34.2	.50	.55	4.0	Green.	Round.
Crystal White Wax	Burpee	61	15.0	28.0	.63	.55	3.0	Whitish green.	Roundish thick.
Vienna Forcer	Thorburn	69	17.8	22.0	.41	.52	5.0	Green.	Flat, thick.
Dwarf Chocolate	Thorburn	60	8.3	23.8	.26	.45	5.0	Dark green.	Flat, thin.
Giant Stringless Green Pod	Burpee	60	13.0	28.5	.65	.97	5.0	Green.	Round.
First in Market	Landreth	60	9.8	23.0	.65	.84	4.5	Green.	Flat, thin.
Improved Golden Wax	Burpee	60	15.5	21.3	.86	.58	4.0	Yellow.	Flat, thick.
Fillbasket Wax	Thorburn	53	2.3	10.8	.18	.70	3.5	Yellow.	Round.
Victoria Dwarf Flageolet	Thorburn	60	4.8	24.8	.96	1.38	5.0	Green.	Flat.
Jones' Stringless Wax	Thorburn	60	8.0	24.8	1.00	1.18	3.0	Yellow.	Round.
Scarlet Wax	Landreth	60	22.3	27.8	.52	.53	5.0	Yellow.	Flat, thick.

TABLE 25.

Lima Beans—Bush vs. Pole Varieties.

VARIETY.	Date first edible pods.	Amount of first picking.	Total yield.	Number vines.	Yield per vine.
		lbs. oz.	lbs oz.		oz.
Burpee's Bush, Burpee	Sept. 1.	4— 8	12—13	165	1.40
Dreer's Bush, Dreer	Aug. 29.	8— 3	11—10	193	1.14
Large White Pole, Burpee	Sept. 1.	7—14	20—14	100	1.87
Dreer's Imported Pole, Dreer	" 1.	5— 0	10— 2	73	1.97

There has not been much difference in earliness of maturing, but quite a little difference in amounts yielded in these first pickings. The pole sorts are by far the most productice. The great value of the bush sorts lies in avoiding the necessity of securing aud setting a trellis or poles. Also allows of rather closer planting.

PEAS—VARIETIES.

Twenty-uine varieties have been grown and records made each season. Table 26 contains the averages of these records.

TABLE 26.

Peas—Varieties.

VARIETY.	Seedsman.	Days to marketable maturity.	Amount of first picking.	Total yield.	Yield per vine.	Weight per vine.	Per cent. edible.	No peas per pod.
			oz.	oz.	oz.	oz.		
Alaska	Johnson & Stokes	52	6.3	9.2	.17	.12	46	4.9
XXX Extra Early	Burpee	52	4.7	7.0	.12	.37	46	4.8
Surprise	Thorburn	52	4.2	5.0	.21	.38	50	4.8
Extra Early Pioneer	*Dreer*	*52*	*6.3*	*7.8*	*.16*	*.07*	*49*	*4.3*
Electric Extra Early	Dreer	52	7.0	9.2	.10	.08	46	4.4
Ameer	Dreer	57	5.3	5.8	.41	.28	38	3.7
Premium Gem	Burpee	57	6.5	7.2	.50	.25	50	4.2
Carter's Daisy	Burpee	67	3.3	3.3	.18	.66	......	......
Nott's Excelsior	Johnson & Stokes	52	7.0	8.5	.18	.12	47	4.5
Improved Dan O'Rourke	Henderson	52	7.0	8.5	.15	.08	48	4.8
Advancer	Johnson & Stokes	67	7.0	7.3	.49	.25	49	4.4
Quality	Burpee	67	6.3	7.5	.21	.21	56	3.8
Boston Unrivaled	Burpee	67	4.2	4.8	.12	.58	46	4.5
Admiral	Henderson	67	4.7	6.5	.28	.44	57	5.7
Perfect	Burpee	67	1.8	4.3	.35	.59	......	......
Dwarf Telephone	Dreer	67	3.2	4.2	.20	.47	......	......
Prosperity	Henderson	57	4.7	5.0	.16	.12	44	3.3
Gradus	Burpee	57	5.0	5.8	.18	.15	38	3.5
Victory	Henderson	67	1.2	4.5	.32	.49	47	6.5
Heroine	Burpee	67	4.7	8.2	.17	.25	50	6.2
Champion of England	Burpee	67	1.8	7.3	.23	.68	45	3.9
Pride of the Market	Burpee	67	4.7	8.2	.27	.40	48	6.9
The Alderman	Burpee	67	4 7	6.5	.22	.36	45	5.2
Telephone	Dreer	67	6.7	8.3	.39	.50	45	6.3
St. Duthus	Burpee	67	2.7	8.8	.41	1.04	......	......
Improved Pride of the Market	Burpee	67	6.8	9.2	.20	.33	43	6.8
Bloomsdale	Landreth	66	7.3	8.3	.09	.14	48	6.4
Extra Early	Landreth	53	10.5	10.8	.16	.07	48	4.9
Nott's New Perfection	Maule	60	10.3	11.8	.27	.21	51	4.2

Of the early smooth sorts, none are superior to the Alaska, a standard of this class. Extra Early Pioneer is a close second, likewise an old standard. Nott's Excelsior, of the early wrinkled varieties, is not as productive as usual. Surprise is one of the earliest and most productive of this class. Premium Gem matures five days later and yields over twice as much per vine. Under the conditions of the test, the earlier sorts have given the best results. Premium Gem is the most productive sort, with Advancer maturing ten days later, giving very nearly as large returns. Nott's New Perfection is a desirable newer sort—a little later and a little taller growing than Nott's Excelsior.

Considering the next to last column of table, the per cent. of total weight that is edible, the range is from 33 per cent. in Ameer to 57 per cent. in Admiral—a difference of considerable importance to the consumer. Next to Admiral, the varieties giving the largest per cents. edible and in order are: Quality, 56; Nott's New Perfection, 51; Surprise, Premium Gem and Heroine, 50 each; Advance and Extra Early Pioneer, 49 each.

The medium early, wrinkled sorts, planted to give a succession, have proven the most satisfactory.

TOMATOES—VARIETIES.

Twenty-nine varieties have been grown. Seeds of these sorts were started in the forcing-house about the middle of March, handled twice in pots and set in the field May 15th to 20th, varying with the season. Four plants of each variety were used in a test. Good field culture was given and records made as required in all cases. Table 27 contains the averages of the yearly records, and shows quite plainly the results of the comparisons.

TABLE 27.

Tomatoes—Varieties.

VARIETY.	Seedsman.	Days to ripe fruits.	Early Yield. Number.	Early Yield. Weight.	Total Marketable Fruits. Number.	Total Marketable Fruits. Weight.	Total Marketable Fruits. Average per fruit.	Culls. Number.	Culls. Weight.	Culls. Per cent. of total.	Rotten. Number.	Rotten. Weight.	Rotten. Per cent of total.	Color of fruits.
				lbs. oz.		lbs. oz.	oz.		lbs. oz			lbs. oz.		
Aristocrat	Henderson	71	20	5— 6	76	17—15	3.8	39	5— 2	22.9	7	1— 2	4.5	B. red.
Beauty	Burpee	67	23	7—10	101	32— 8	5.3	36	6—10	15.0	6	1— 9	3.7	Pink.
Best of All	Livingston	74	14	5—13	137	45— 8	5.5	13	2— 5	4.9	8	2— 2	4.3	Red.
Combination	Burpee	70	19	6— 0	107	32— 2	4.9	32	5—12	14.6	9	1—15	5.4	Red
Dwarf Golden Champion	Burpee	73	9	2— 5	57	13—13	4.0	36	5— 3	25.2	8	1— 6	6.8	Yellow.
Earliest	Maule	77	35	10— 0	97	27—14	4.7	39	5— 8	14.0	24	4—10	12.3	Red.
Early Bird	Johnson & Stokes	66	37	7— 4	76	11— 7	2.6	154	17— 0	53.4	25	3— 4	9.0	Pink.
Early Dwarf Prolific	Burpee	77	22	3—13	44	7—10	2.8	269	23— 3	76.3	19	1—14	6.2	Red.
Early Ruby	Henderson	64	27	7— 9	97	25—11	4.2	36	5— 9	23.0	16	3— 8	8.6	Red.
Enormous	Burpee	79	12	6— 8	64	30—15	7.9	36	3— 6	7.7	13	4— 8	10.2	Red.
Early Richmond	Landreth	77	46	12— 6	119	28— 5	3.8	54	8— 6	17.6	10	1—15	5.6	Red.
Fordhook Fancy	Burpee	67	10	2— 6	58	13— 6	3.7	52	6—15	33.9	9	1— 9	8.0	Pink.
Fordhook First	Burpee	67	23	6— 4	89	23—13	4.3	40	6—15	23.5	14	2—11	7.6	Pink.
Freedom	Henderson	69	21	4—12	84	20— 0	3.8	73	8—12	30.7	12	2— 0	6.3	B. red.
Honor Bright	Burpee	74	14	4— 7	78	21— 5	4.5	32	4—10	14.9	14	3— 3	11.7	Red.
Hulsart's Selection	Hulsart	60	40	13— 0	114	31—15	4.6	28	4—11	12.6	20	4— 0	9.1	Red.
Kansas Standard	Kansas Seed House	76	12	3—15	96	29— 5	4.9	18	3— 4	11.0	9	1— 5	4.6	Red.
Magnus	Vaughan	80	11	4— 3	117	37— 3	5.2	26	5—13	10.8	12	3—11	7.4	Pink.

TABLE 27—Continued.

Tomatoes—Varieties.

VARIETY.	Seedsman.	Days to ripe fruits.	Early Yield.		Total Marketable Fruits.			Culls.			Rotten.			Color of fruits.
			Number.	Weight.	Number.	Weight.	Average per fruit.	Number.	Weight.	Per cent. of total.	Number.	Weight.	Per cent. of total.	
				lbs. oz.		lbs. oz.	oz.		lbs. oz.			lbs. oz.		
Matchless	Burpee	77	10	4—3	114	39—2	5.5	15	2—5	6.4	8	2—5	4.4	Red.
Money Maker	Johnson & Stokes	70	15	4—4	95	24—15	4.3	32	4—14	19.0	18	2—11	8.2	Pink.
Optimus	Dreer	73	14	4—8	121	35—10	4.8	25	4—0	10.9	12	2—9	5.9	Red.
Perfection	Livingston	67	17	5—10	96	30—5	4.9	30	5—0	16.4	10	2—7	6.4	Red.
Quarter Century	Burpee	77	16	5—5	86	23—4	4.3	19	3—2	10.4	14	2—14	8.4	Red.
Rosalind	Thorburn	77	5	1—12	75	28—0	6.2	19	4—3	10.6	5	1—4	4.4	Pink.
Success	Maule	85	16	5—14	132	19—11	4.2	31	4—7	10.0	14	2—15	6.9	Red.
Truckers' Favorite	Burpee	69	18	6—3	128	39—2	5.0	34	5—5	11.8	13	3—0	6.4	Pink.
T. T. T.	Landreth	69	36	10—13	140	42—5	4.9	43	5—11	11.2	11	2—11	5.8	Red.
Virginia Corker	Landreth	79	23	8—2	169	48—11	4.6	27	4—6	7.1	8	1—14	3.2	Red.
White's Excelsior	Maule	80	24	8—7	131	38—2	4.7	38	5—11	11.7	19	4—9	9.5	Pink.

In earliness of maturing the variety termed Hulsart's Selection leads by four days any other sort. This is a variety developed by selection by Mr. C. C. Hulsart, the well-known grower of tomatoes of Monmouth county. In growth it resembles the Early Ruby, but for the total yield of marketable fruit it averages .4 ounces larger per fruit, and is not as rough and irregular as the Ruby.

The early yield is rather arbitrarily set, but includes the first half dozen pickings. The variety Hulsart's Selection exceeds in early yield Early Richmond, the next in order, by 2½ ounces per plant, T. T. T. tomato by 9 ounces per plant, and Earliest by 12 ounces per plant. The next four varieties in order of early yield are White's Excelsior, Virginia Corker, Beauty and Early Ruby. In total yield of marketable fruit Virginia Corker leads, with Best of All second. T. T. T., Matchless, Truckers' Favorite, White's Excelsior, Magnus, Optimus, Beauty, Combination, Hulsart's Selection and Enormous, are the next ten in order of yield of marketable fruit. Enormous gives the largest average weight per fruit, 7.9 ounces. Others having the heaviest fruits are Rosalind, 6.2 ounces; Best of All, 5.5 ounces; Matchless, 5.5 ounces; Beauty, 5.3 ounces; Magnus, 5.2 ounces, and Truckers' Favorite, 5 ounces.

In keeping records, the proportion of culls and of rotten fruit was each year determined. In the proper columns in the table the numbers and weights of tomatoes grading as culls and rotten are given, and following each is the percentage each is of the total yield of that variety. Best of All shows the smallest per cent. of culls and stands third in lowest per cent. of rotten fruit. Matchless, Virginia Corker and Enormous are other varieties having small percentage of culls. On the other hand, over three-fourths of the total yield of Early Dwarf Prolific graded as culls, and in Early Bird 53.4 per cent. were culls. Virginia Corker gave the lowest percentage of rotten fruit, with Beauty next in order; then follows Best of All, Matchless and Rosolind. Earliest and Honor Bright show the largest percentage of rotten fruit.

TOMATOES—LARGE VS. SMALL SEED.

In the last vegetable report,* we noticed the beneficial effect of using the first plants to appear in the seed plot in comparison with those germinating more slowly—three days' difference. Continuing the study further, 50 of the largest and 50 of the smallest, yet well-formed seed of the Beauty variety, were selected. These we planted in plots in the forcing-house, and from two to three days difference was noted in the germination, the larger ones appearing first. The treatment thereafter was identical. Table 28 contains the averages of three seasons' records. The last column contains the weight of the 50 seeds planted in each case.

TABLE 28.

Tomatoes—Large vs. Small Seed.

BEAUTY	Days to first ripe fruit.	Early Yield.		Total Marketable Fruit.			Culls.			Rotten.			Weight of 50 seeds planted.
		Number.	Weight.	Number.	Weight.	Average per fruit.	Number.	Weight.	Per cent. of total.	Number.	Weight.	Per cent. of total.	
			lbs. oz.		lbs. oz.	oz		lbs. oz.			lbs. oz.		grms.
Large Seed......	73	24	7—15	103	29—15	4.8	38	6—14	17.1	12	2—12	6.4	.176
Small Seed......	69	18	5— 7	97	29— 8	4.9	88	6— 6	18.2	9	1—13	4.7	.071

The small seed gave ripe fruit four days earlier, but in the early yield the plants from the large seed gave 10 ounces per plant more than was obtained from the small seed plants. In total yields a slight difference exists in favor of the use of large seed. The plants from large seed yielded a smaller percentage of culls but a larger percentage of rotten fruits. The after care of the plants has more to do with the yields obtained than has the selection of seed.

* Annual Report 1898, page 188.

TOMATOES—EARLY AND LATE STARTING.

This question was considered in the 1898 report,* starting the first plants February 26th, and thereafter every ten days until April 7th, giving five lots. The results were not definite. This question of earliness of starting was then continued, commencing earlier and *giving a longer time between starting the different lots, i. e.*, February 1st, February 15th, March 1st, March 15th and April 1st. The seedlings were handled in pots as occasion demanded, otherwise the treatment throughout was identical. Table 29 contains the results of three seasons' work, as outlined.

TABLE 29.

Tomatoes—Early and Late Starting.

DATES OF SOWING SEED.	Times handled.	Days to ripe fruits.	EARLY YIELD.			TOTAL MARKETABLE FRUIT.			CULLS.			ROTTEN.		
			Number.	Weight.	Average per fruit.	Number.	Weight.	Average per fruit.	Number.	Weight.	Per cent. of total.	Number.	Weight.	Per cent. of total.
				lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.			lbs. oz.	
February 1...	5	72	80	9— 4	4.9	110	82— 8	4.7	56	8— 9	19.4	15	3— 0	6.8
February 15...	4	67	28	9— 2	5.2	116	35— 8	4.9	48	7— 8	16.2	15	3— 8	6.9
March 1...	3	67	27	8— 7	5.0	107	32—13	4.9	42	7— 5	17.8	6	1— 1	2.6
March 15...	3	71	19	6— 8	5.5	89	27— 5	4.9	41	6— 7	18.4	6	1— 5	3.7
April 1...	2	70	20	7—12	6.2	87	29—12	5.5	24	4—13	12.9	11	2—11	7.2

The first column shows the number of times the plants were handled, increasing the size of pot each time. The second column shows that those started February 15th and March 1st matured fruits at the same time, and earlier than the other lots, dating from time set in field. In early yield the first lot exceeds the second by only two ounces, a half ounce per plant, too small an increase to be of practical value, considering the extra cost. Considering the total

* Annual Report 1898, page 185.

yield, the second lot, started February 15th, gives almost eleven ounces per plant more than any other lot. Those started March 1st are second in yield. The results obtained as above point to the latter half of February as the best time to start the seed, and requires handling three or four times.

REPORT OF THE ASSISTANT IN DAIRY HUSBANDRY.

DAIRY HUSBANDRY.

The work in this department during the past year has been chiefly along the lines followed in several previous years, the principal subjects of investigation being as follows :

The study of forage crops, including crop rotations, cost and yield of forage and new varieties.

The retail milk business, including the cost of production and sale and wastes in handling and delivery.

As in previous years, daily records have been kept by the dairy herd, and the milk of each animal has been analyzed weekly, the results of which are reported.

During the past five years considerable time has been given to the analysis of milk by the "Babcock" method, the number of analyses amounting to 9,000. In addition to the regular work in this direction, samples have frequently been sent to the Station by Farmers, Dairymen and by Breeders' Associations.

In the spring a new wing was built to the main dairy barn, a description of which is given in this report.

Experiments have been conducted with Oat and Pea Straw, Feed and Hay, for the purpose of studying their relative value and influence upon the growth of animals.

The use of the Right Lap Cutaway in summer seeding was made the subject of an experiment, the results of which are reported.

Experiments were made in growing cow peas and corn for silage, preliminary to a further study of the feeding value of this combination of crops.

Experiments have been conducted with seeding grass without the use of a cover crop. A study was also made of the relative value of manures and fertilizers in the production of grass.

Experiments were made in constructing farm roads of different materials, including cinders, gas lime and stone lime.

The dairy business in relation to soil exhaustion has been studied for the past five years, and the results showing the gains and losses to the farm are reported.

Since the last report was issued, Bulletin No. 148, "Alfalfa, Methods of Culture and Yields per Acre—Alfalfa Protein versus Purchased Protein in Rations for Dairy Cows," has been published. The bulletin included the following summary :

Summary.

1. The successful establishment of alfalfa requires :
   a. That the surface soil shall be well supplied with the mineral elements, lime, phosphoric acid and potash.
   b. That during the early growth of the crop, the weeds should be frequently cut.
   c. That the crops should be harvested preferably just before the plants are in blossom.
2. The crop is well adapted for soiling and for hay. The average yield of green forage per acre for three years (including the first year), was 18.27 tons, equivalent to 4.57 tons of hay. The yield the third year from five cuttings was 26.6 tons of green forage, equivalent to 6.65 tons of hay, costing $3.69 per ton.
3. A feeding experiment showed that the protein in alfalfa hay could be successively and profitably substituted in a ration for dairy cows for that contained in wheat bran and dried brewers' grains, and for this purpose is worth $11.16 per ton, when compared with the wheat bran and dried brewers' grain at $17 per ton.
4. The use of alfalfa hay reduces the necessity for the purchase of protein feeds.

SOILING CROPS, 1901.

The season of 1901 was generally favorable for the growth of forage crops. With the exception of the month of June (rainfall .81 inches), crops were not seriously affected by drought. Fifteen kiuds of forage were grown. Some new varieties tested in previous years were given further trial. The herd, including young stock, was equivalent to fifty full-grown animals. The arrangement of forage crops, shown in Table I., furnished a continuous supply from May 1st until November 1st. About one and one-half tons of green forage were cut each morning to supply the herd for the day. This was fed to the cows in a two-acre field, where they were turned every morning for exercise. The amount of forage fed varied according to the kind of fodder and the requirements of the individual

animal. The average amount per day was practically sixty pound per cow. In addition to the roughage used in summer, the cows received a feed ration mixed in the following proportion :

Wheat bran	4 pounds.
Dried brewers' grains	4 "
Corn meal	2 "

and fed according to the needs of the individual animals. A careful record was kept of the cost of producing each crop, time of cutting and sowing and the yield per acre. Data concerning crops grown in 1901 are contained in the following table :

TABLE I.

Cost and Yield of Soiling Crops.

KIND.	Seed used—bushels.	Date of seeding.	COST OF— Labor.	COST OF— Seed.	COST OF— Fertilizers.	Period of cutting and feeding.	Yield—tons.	Total cost.
Rye, 2 *acres*	4	Sept. 27, '00	$1 20	$2 40	....	May 1– 7	9.4	$3 60
Rye, 2 acres	4	Oct. 3, '00	5 00	2 40	....	" 7–19	19.2	7 40
Alfalfa, 1st cutting	$\frac{7}{12}$	May 14, '98	....	....	....	" 19–25	11.1	....
Wheat, 2 acres	4	Sept. 26, '00	5 00	3 40	....	" 25 to June 1	10.4	8 40
Crimson Clover, 6 acres,	1½	July 16, '00	3 60	4 20	....	June 1–21	42.8	7 80
Mixed Grasses, 1 acre	....	....	....	....	....	" 21–26	8.8	....
Oats and Peas, 2 acres	{ 4 / 3 }	April 2	5 40	4 81	$4 90	" 26 to July 4	12.4	15 11
Oats and Peas, 2 acres	{ 4 / 4 }	" 11	6 00	5 96	6 86	July 4– 9	8.2	18 82
Alfalfa, 2d cutting	....	....	....	....	....	" 9–11	2.1	....
Oats and Peas, 5 acres	{ 10 / $\frac{7}{12}$ }	" 19	15 00	14 65	12 85	" 13–22	16.4	42 50
Southern White Corn, 2 acres	½	May 2	12 00	25	6 24	" 22 to Aug. 3	17.7	18 49
Barnyard Millet, 2 acres	1⅜	June 19	6 00	1 48	7 46	Aug. 3–19	23.2	14 94
Soy Beans, 1 acre	2	" 10	3 00	4 50	3 33	" 19–25	8.8	10 83
Cow Peas, 1 acre	2	" 10	3 00	3 00	3 33	" 25 to Sept. 1	10.5	9 33
Cow Peas and Kaffir Corn, 2 acres	{ 2 / 1 }	July 10	6 30	6 76	5 68	Sept. 1–16	24.4	18 74
Pearl Millet, 2 acres	¼	" 11	3 00	8 00	5 42	" 16 to Oct. 1	20.2	16 42
Cow Peas, 1 acre	1½	" 24	4 20	2 25	1 48	Oct. 1– 5	8.0	7 93
Mixed Grasses, partly dried	....	....	....	....	....	" 5–27	20.0	....
Barley, 2 acres	3½	Sept. 2	7 20	2 45	3 54	" 27 to Nov. 1	5.2	13 19

GENERAL REMARKS CONCERNING CROPS.

Rye and Wheat.—Rye is our first forage crop, and is usually ready for cutting the first week in May. Four acres were grown for soiling this year. The yield ranged from 4.7 to 9.6 tons per acre, and averaged 7.2 tons.

Wheat follows rye very closely in the forage rotation. Two acres were grown this season. The yield was light, owing to the fodder being cut early in order to seed the land to other crops. The average yield of wheat was 5.2 tons per acre.

Alfalfa.—The acre of alfalfa sown May 14th, 1898, was cut four times this season. The yield at each cutting was as follows: May 19th, 11.14 tons; July 9th, 2.8 tons; August 11th, 1.17 tons hay, equivalent to 4.68 tons green forage; September 28th, 0.77 tons hay, equivalent to 3.08 tons green forage. The total yield for the year was 21.7 tons of green forage. The following table shows the yield of alfalfa and the cost per acre for four years:

TABLE II.

The Yield of Alfalfa and the Cost Per Acre for Four Years.

	Seed—pounds.	Date of seeding.	YIELD—TONS.		COST OF—				Total cost.
					LABOR.				
			Green forage.	Equivalent to hay.	Seeding.	Harvesting.	Seed.	Manures and fertilizers.	
First year	80	May 14, '98	8.00	2.00	$8 65	*$1 92	$3 15	$23 65	$37 37
Second year	.....	.....	20.21	5.05	.....	4 86	.....	20 83	25 69
Third year	.....	.....	26.60	6.65	.....	6 39	.....	18 15	24 54
Fourth year	.....	.....	21.70	5.43	.....	5 21	.....	17 75	22 96
Total	80	.....	76.51	19.13	$8 65	$18 38	$3 15	$80 38	$110 56
Average	.....	.....	19.13	4.78	.....	4 60	.....	20 10	27 64

* On hay basis.

Two more acres of alfalfa were seeded May 5th, 1900, as an experiment on land that had not received any special preparation in previous years. A fair stand was secured at the start, but weeds and grass

gradually took possession of the ground, and it was turned under the second year. The results emphasize the fact that in order to succeed with alfalfa, it is necessary to grow a cultivated crop for several years previous to seeding in order to destroy the weeds.

Two and one-half acres of alfalfa were also seeded this spring (1901) under more favorable conditions. A fair stand was secured and the field is looking well, November 6th.

Crimson Clover.—This plant has proved very valuable in the forage rotation. It is sown in the corn in July at a small expense, and serves as a cover crop through the winter. In the spring the clover makes a rapid growth and is usually ready for cutting the last week in May. Six acres yielded 42.8 tons of forage. Crimson clover also makes excellent hay. Experiments are now in progress to test its feeding value, the results of which will be given in fnture reports.

Oats and Peas.—Probably no forage crop is more commonly grown by dairymen than oats and peas. They yield well when there is a normal amount of rainfall. The drought in June retarded their growth this season. The yield on four acres ranged from 4.1 to 6.2 tons per acre.

Southern White Corn.—A valuable crop for mid-summer feeding also grows well until the first frost. In favorable seasons two crops can be grown on the same area. Two acres were planted for forage this year and yielded at the rate of 9.0 tons per acre.

Cow Peas and Soy Beans.—These crops are rich in nitrogen, and have the power of resisting drought, hence they occupy an important place in the forage rotation. Cow peas usually produce a higher yield, than soy beans, and are more succulent. This season the yield of cow peas ranged from 8.0 to 10.5 ton, while the soy beans yielded 8.8 tons per acre.

Barnyard Millet.—This variety has been grown on the farm for several years, and has given good results. In favorable seasons a good crop can be secured in forty days. The average yield per acre this year was 11.6 tons.

Pearl Millet.—Like the barnyard millet, this crop makes a rapid growth, and yields well when there is an abundance of moisture. Owing to its high content of water, its feeding value is not as great as the barnyard variety. When allowed to mature, tbe yield is somewhat heavier than barnyard millet.

Mixed Grasses.—Owing to drought or delay in seeding, it sometimes happens that gaps occur in the forage rotation for a few days. At such times it is convenient to have a few acres of mixed grasses

or clover to aid in keeping up a continuous supply of fodder. Animals like a change in the ration, and are very fond of this kind of forage. A field of mixed grasses is shown in Fig. 3.

Barley.—This is the latest forage we feed in the fall, and when seeded in August it usually yields well, making some growth even after the weather becomes cool. The yield was low this year, for the reason that the plots were not seeded until September. Two acres produced 5.2 tons.

Special Crops.

White Flint Corn.—A very desirable variety for forage, owing to its suckering habit and vigorous leafy growth. Yields ranging from ten to sixteen tons per acre have been secured. Fig. 1 shows a hill of five stalks, produced from one seed. Four of the stalks have well-developed ears.

Cow Peas and Kaffir Corn.—Two acres of this combination of crops were grown this season. It is a very nutritious fodder and much relished by dairy animals. The two acres yielded 24.4 tons.

Sorghum.—This plant was grown for the first time in 1899, and yielded 12.8 tons per acre. It was given a further trial this season, and yielded 14.0 tons per acre. Sorghum contains a high content of water (85.19 per cent.), and is much inferior to Indian corn in feeding value. It has one advantage, however, over many of our forage crops, in that it thrives well in a dry season. The entire crop this year was put into the silo. A crop of sorghum is shown in Fig. 2.

Cow Peas and Corn as a Silage Crop.

This combination of crops was grown as an experiment, the object heing (1) to see whether the two crops could be cut together with a corn harvester; (2) to place the mixture in the silo and study its keeping qualities and feeding value.

The corn (Southern White) was planted June 23d, in drills, three and one-half feet apart, the stalks standing nine inches apart in the drill. After the first cultivation (July 17th), cow peas (Wonderful) were planted in drills as near the corn as possible, at the rate of one peck per acre. Fig. 6 shows the crop just before harvesting (September 26th). Both the corn and cow peas made a vigorous growth, the corn acting as a support for the peas. It is believed, however, that it would be a better plan to plant the cow peas and corn at the same time. The crop was cut with a corn harvester, which bound the

cow peas in with the corn without any difficulty. Further, no difficulty was experienced in running the two crops through the silage cutter into the silo, and it is believed that this combination of crops will make a valuable ration for dairy animals. At this time, however, we are not able to report upon its keeping qualities and feeding value, but the results may be expected in further reports.

The Right Lap Cutaway.

This machine takes the place of a plow and was used in seeding several of our forage crops this season. Fig. 7 shows the cutaway at work. It has five turning disks, twenty-four inches in diameter, which can be adjusted to cut from three to six inches deep. Five smaller disks on the left side cut the surface soil and prepare it for the heavy disks which follow. The machine is drawn by four horses and does the work much more rapidly than the ordinary plow. It has the advantage (1) of preparing the ground at one operation, thus saving time and expense; (2) it pulverizes the soil to such a fineness that more moisture is retained than when the ordinary plow is used; (3) the cutaway can be used to prepare ground which has become too hard to plow, and for this reason is particularly valuable. Fig. 8 shows crop of cow peas and Kaffir corn put in with this machine.. The crop followed oats and peas, and yielded 12.2 tons per acre.

Seeding Grass Without Grain.

A field of nine acres was seeded to grass September 20th, 1900, after a crop of oats and peas had been removed. The land was prepared by harrowing and rolling alternately until the soil was solid, with a very fine seed bed. A mixture containing the following amounts of seed was used per acre: 7.5 pounds timothy, 5 pounds red top, 3 pounds alsitke clover, 5 pounds red clover and 1.5 pounds of Kentucky blue grass. Six of the nine acres had received manure at the rate of eight tons per acre, and acid phosphate at the rate of 150 pounds per acre, at the time of seeding the oats and peas. The remaining three acres received an application of 300 pounds of fertilizers per acre mixed, in the following proportion:

50	pounds	nitrate of soda.
50	"	ground bone.
50	"	muriate of potash.
150	"	acid phosphate.

The seed came up well, and as the conditions were favorable, grew nicely throughout the late summer and fall. The grasses showed an excellent stand in the spring, but only a small percentage of the clovers survived the winter. Early in the spring the six acres, previously treated with yard manure, received another application at the rate of 5 tons per acre, while the three fertilized plots received 350 pounds per acre, of the following mixture :

150 pounds of ground bone.
100 " " muriate of potash.
100 " " nitrate of soda.

The crop grew remarkably well on the whole field, lodging on portions of the fertilized plots. Cutting began June 26th, and the average yield of cured hay per acre on the manured plots was 3.0 tons, and on the fertilized plots 3.11 tons. A second crop was also secured in October, which was fed green to the dairy herd. These results show that it is possible, by thoroughly preparing the soil and applying a liberal amount of either manure or fertilizer, to secure a good crop of hay without a grain crop. Fig. 9 shows the hay field at time of harvesting.

Experiment With Feeding Oat and Pea Feed and Straw versus Oat and Pea Hay.

The increase in the price of feeds commonly used in the dairy naturally causes the dairyman to look about for some bye-product in manufactories, or some food that can be produced on the farm to take the place of the high-priced feeds, which in previous years he has purchased at a much lower figure. There are many crops that can be produced on the farm, such as alfalfa, crimson clover, oats and peas, and cow peas, which make excellent hay. These crops are rich in nitrogen, and will, in a large measure, take the place of purchased feeds.

The object of this experiment with Oat and Pea Feed and Straw and Oat and Pea Hay was to study the relative value of these foods and their influence upon :

I. The Yield of Milk.
II. The Composition of Milk.
III. The Economic Production of Milk and Butter.
IV. The Individual Animals.

The experiment began December 14th and continued through January 12th—thirty days. Four cows were included in the test,

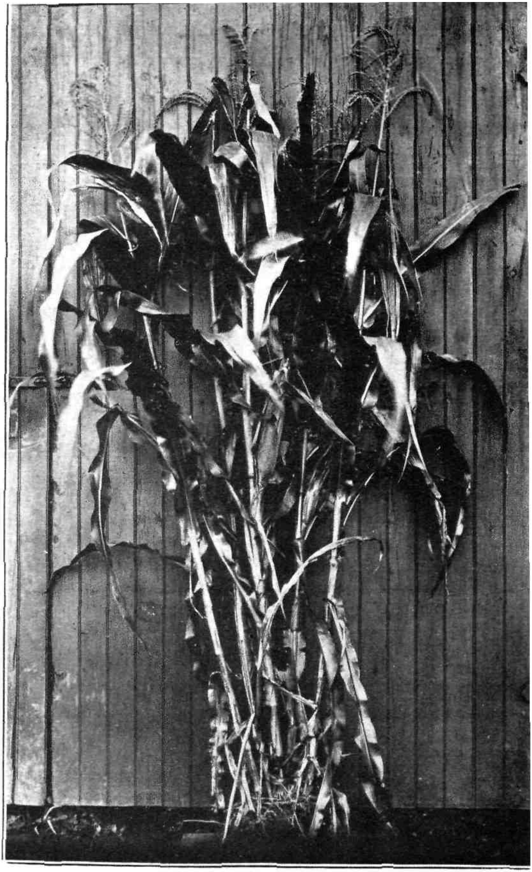


Fig. 1.
Showing hill of Southern White Corn, produced from one seed.

Fig. 2.
A crop of Sorghum. Yield, 14 tons per acre.

Fig. 3.
A Crop of Mixed Grasses, used for Forage.

Fig. 4.
A Crop of Barnyard Millet.

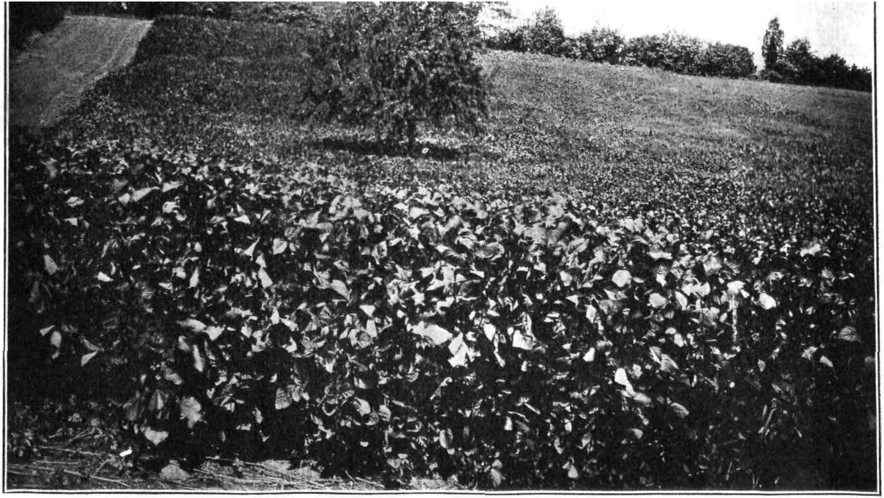


Fig. 5.
A Crop of Soy Beans

Fig. 6.
A Crop of Cow Peas and Southern White Corn.

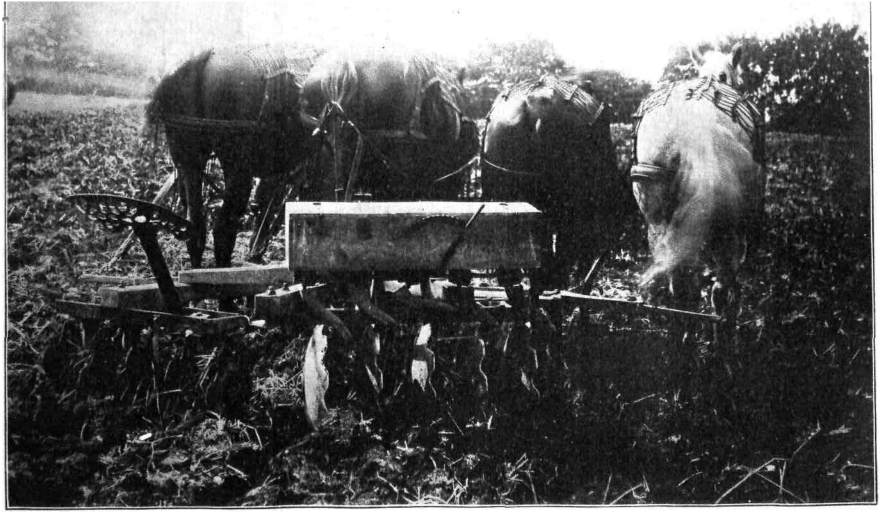
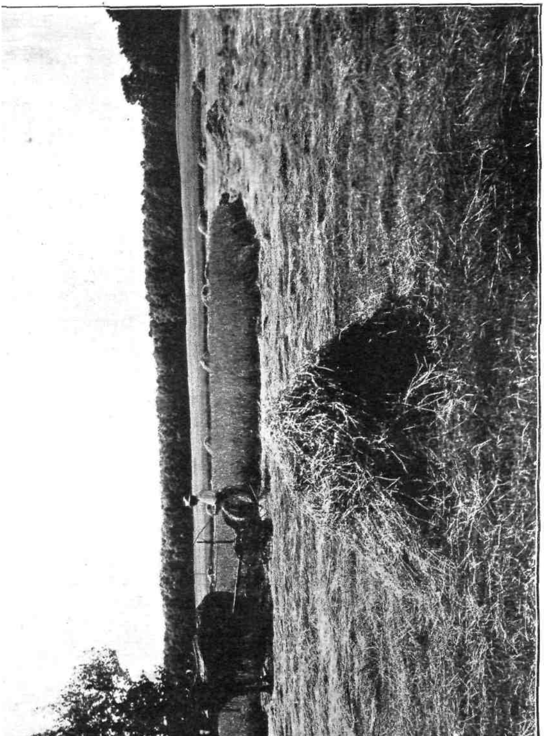


Fig. 7.
Right-Lap Cutaway at Work.

Fig. 8.

A Field of Cow Peas and Kaffir Corn   Ground prepared with Right-Lap Cutaway.



divided into lots of two cows each. At the beginning of the test, the average weight of the cows in Lot I., was 985 pounds, and in Lot II., 1,050 pounds.

The Rations Used.

OAT AND PEA FEED AND STRAW RATION.			Dry matter.	TOTAL. Protein.	Fat.	Carbohydrates.	Estimated nutritive ratio.
			lbs.	lbs.	lbs.	lbs.	
30 pounds Silage			7.69	.51	.24	5.10	....
5	"	Oat and Pea Straw	4.72	.25	.10	4.00	....
7	"	Oat and Pea Feed	6.31	1.17	.27	4.54	....
3	"	Cotton-Seed Meal	2.76	1.27	.38	.89	....
Total			21.48	3.20	.99	14.53	1 : 5.2

Oat and Pea Hay Ration.

30 pounds Silage			7.69	.51	.24	5.10	....
14	"	Oat and Pea Hay	13.22	1 23	.37	10.57	....
3	"	Cotton-Seed Meal	2 76	1.27	.38	.89	....
Total			23 67	3.01	.99	16.56	1 : 6.0

The two rations contained practically the same amount of protein and fat, while the dry matter and carbohydrates were slightly greater in the hay ration. The nutritive ratio in the Oat and Pea Feed and Hay Ration was estimated at 1:5.2 and 1:6.0, respectively.

I. THE YIELD OF MILK AND FAT.

The milk from each cow was weighed daily, and sampled and analyzed once a week, to obtain percentage of butter fat. Table III. shows the daily yield of milk and its composition, as well as the total yield of milk and of fat per cow during each period of the test.

TABLE III.

Lot I.—First Period. *OAT AND PEA FEED AND STRAW.* **Lot II.—First Period.** OAT AND PEA HAY.

	COW NO. 1.			COW NO. 2.			COW NO. 3.			COW NO. 4.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
	lbs.	*p. c.*	*lbs.*	*lbs.*	*p. c.*	*lbs.*	*lbs.*	*p. c.*	*lbs.*	*lbs.*	*p. c.*	*lbs.*
December 14...	27.9	....	....	28.3	....	....	30.5	....	....	20.4	....	....
" 15...	29.2	....	....	30.9	....	....	31.5	....	....	19.9	....	....
" 16...	29.6	....	....	30.0	....	....	31.0	....	....	20.7	....	....
" 17...	30.7	....	....	33.6	....	....	32.3	....	....	20.6	....	....
" 18...	30.0	....	....	30.7	....	....	30.1	....	....	19.0	....	....
" 19...	30.9	....	....	31.7	....	....	31.4	....	....	18.8	....	....
" 20...	29.4	4.3	8.93	32.6	4.6	10.02	31.4	4.6	10.04	18.6	4.1	5.66
" 21...	28.8	....	....	31.2	....	....	31.1	....	....	18.4	....	....
" 22...	30.6	....	....	32.5	....	....	31.1	....	....	19.8	....	....
" 23...	29.1	....	....	30.8	....	....	28.9	....	....	18.9	....	....
" 24...	30.4	....	....	33.8	....	....	32.9	....	....	18.7	....	....
" 25...	29.0	....	....	30.9	....	....	31.4	....	....	18.4	....	....
" 26...	31.8	....	....	34.5	....	....	31.5	....	....	18.2	....	....
" 27...	29.9	....	....	33.3	....	....	27.9	....	....	18.0	....	....
" 28...	29.1	4.3	10.26	33.6	4.4	11.47	29.6	4.7	11.49	19.1	4.1	6.13
Total	446.4	....	19.19	478.4	....	21.49	462.6	....	21.53	287.5	....	11.79
Average...	29.8	4.30	1.28	31.9	4.49	1.43	30.8	4.65	1.44	19.2	4.10	.79

Lot I.—Second Period. OAT AND PEA HAY. **Lot II.—Second Period.** OAT AND PEA FEED AND STRAW.

	COW NO. 1.			COW NO. 2.			COW NO. 3.			COW NO. 4.		
December 29...	29.1	....	....	30.9	....	....	31.0	....	....	19.2	....	....
" 30...	27.8	....	....	30.4	....	....	28.8	....	....	19.9	....	....
" 31...	27.6	....	....	32.6	....	....	31.3	....	....	20.3	....	....
January 1...	27.3	....	....	31.0	....	....	29.9	....	....	17.7	....	....
" 2...	27.6	....	....	31.6	....	....	30.4	....	....	21.1	....	....
" 3...	27.6	....	....	32.5	....	....	32.3	....	....	19.0	....	....
" 4...	25.8	4.2	8.10	33.4	4.1	9.12	33.2	4.6	9.98	19.9	4.2	5.76
" 5...	29.0	....	....	32.4	....	....	32.2	....	....	20.0	....	....
" 6...	28.4	....	....	32.0	....	....	30.8	....	....	19.0	....	....
" 7...	27.2	....	....	32.8	....	....	33.1	....	....	19.8	....	....
" 8..	27.1	....	....	33.0	....	....	32.0	....	....	19.4	....	....
" 9...	28.4	....	....	33.5	....	....	31.4	....	....	[illegible]	....	....
" 10...	28.9	....	....	32.4	....	....	32.3	....	....	19.3	....	....
" 11...	27.7	....	....	32.6	....	....	33.1	....	....	19.7	....	....
" 12...	26.7	4.3	9.61	31.7	4.0	10.42	31.6	4.6	11.80	20.2	4.2	6.56
Total	416.2	....	17.71	482.8	....	19.54	473.4	....	21.78	293.7	....	12.32
Average...	27.7	4.26	1.18	32.2	4.05	1.30	31.6	4.60	1.45	19.6	4.2	.82

Cows Nos. 1 and 2, constituting Lot I., were fed during the first period, December 14th to 28th, inclusive, on the Oat and Pea Feed and Straw Ration, and cows Nos. 3 and 4 were fed during the same period on the Oat and Pea Hay Ration. In order to equalize the effect of advance in lactation, the rations were reversed at the end of the first period (December 28th), and, beginning with December 29th and continuing through January 12th, Lot I. received the Oat and Pea Hay and Lot II. the Oat and Pea Feed and Straw Ration. It will be observed in the case of Lot I. that cow No. 1 lost 2.1 pounds, or 7.0 per cent., and cow No. 2 gained .3 pounds, or .009 per cent., when changed from the Oat and Pea Feed and Straw Ration to the Oat and Pea Hay Ration. In Lot II., cow No. 3 increased in milk flow on an average of .8 pounds, or 2.6 per cent , and in case of No. 4, four pounds per day, or 2.1 per cent., when changed from the Oat and Pea Hay Ration to the Oat and Pea Feed and Straw Ration. The following table shows the total yield of milk and butter fat from the two rations.

TABLE IV.

Summary of the Test.

	OAT AND PEA FEED AND STRAW RATION.				OAT AND PEA HAY RATION.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
	lbs.	p. c.	lbs.	lbs.	lbs.	p. c.	lbs.	lbs.
Cow No. 1	446.4	4.30	19.19	22.89	416.2	4.26	17.71	20.66
Cow No. 2	478.4	4.49	21.49	25.07	482.8	4.05	19.54	22.80
Cow No. 3	473.4	4.60	21.78	25.41	462.6	4.65	21.53	25.12
Cow No. 4	293.7	4.20	12.32	14.37	287.5	4.10	11.79	13.75
Total and average	1,691.9	4.42	74.78	87.24	1,649.1	4.28	70.57	82.33

The above table shows that 42.8 pounds, or 2.6 per cent. more milk, and 4.21 pounds, or 5.96 per cent. more fat, were produced from the Oat and Pea Feed Ration than from the Oat and Pea Hay Ration.

II. THE COMPOSITION OF THE MILK.

A study of the summary indicates that the composition of the milk was not materially influenced when the cows were changed from the Oat and Pea Feed Ration to the Hay Ration, or the reverse. The following tabulation will show this more clearly :

	OAT AND PEA FEED AND STRAW RATION.	OAT AND PEA HAY RATION.
	Per cent. fat.	Per cent. fat.
Cow No. 1	4.30	4.26
Cow No. 2	4.49	4.05
Cow No. 3	4.60	4.65
Cow No. 4	4.20	4.10
Average	4.40	4.27

Cows Nos. 1, 2 and 4 showed a slightly higher percentage of fat when fed the Oat and Pea Feed Ration, while cow No. 3 was .05 per cent. ahead on the Hay Ration. The average for the four cows is slightly in favor of the Oat and Pea Feed Ration.

III. THE COST OF MILK AND BUTTER FROM THE TWO RATIONS.

The cost of producing milk and butter from the two rations has been calculated, using as a basis the actual cost of producing the foods, namely, \$8.24 per ton for Oat and Pea Hay \$6 per ton for Oat and Pea Straw, \$22.60 per ton for Oat and Pea Feed and \$2.50 per ton for silage. The cotton-seed meal was purchased for \$28 per ton.

The Food Consumed and the Yield and Cost of the Milk and Butter Product.

	Number of days.	FOOD CONSUMED PER COW PER DAY.					Cost of ration.	YIELD OF—		COST TO PRODUCE.	
		Silage.	Oat and pea straw.	Oat and pea hay.	Oat and pea feed.	Cotton-seed meal.		Milk.	Butter.	100 lbs milk.	1 lb. butter.
		lbs	lbs.	lbs	lbs.	lbs.	cts	lbs.	lbs.	cts.	cts.
Oat and Pea Feed and Straw Ration	30	30	5	......	7	3	19.36	1,691.9	87.24	61.6	11.9
Oat and Pea Hay Ration	30	30	.....	14	......	3	13.72	1,649.1	82.33	49.9	10.0

As shown in the table, the cost of food used to produce 100 pounds of milk and 1 pound of butter was 61.6 cents and 11.9 cents respectively for the Oat and Pea Feed and Straw Ration, and 49.9 cents and 10.0 cents for the Oat and Pea Hay Ration. A comparison of the value of the product from the two rations is given in the following tabulation :

	Milk produced, lbs.	Cost per hundred, cts.	Total cost.	Value at 3cts. qt.	Difference between cost and selling price.
Oat and Pea Feed and Straw Ration	1,691.9	61.6	$10 42	$23 61	$13 19
Oat and Pea Hay Ration	1,649.1	49.9	8 23	23 01	14 78

It will be observed that while more milk was produced from the Oat and Pea Feed and Straw Ration, this increase was more than counterbalanced by the greater cost of production, hence the Oat and Pea Hay Ration really proved the more profitable. The gain from the Oat and Pea Feed and Straw Ration and the Oat and Pea Hay Ration over the cost of food is shown to be $13.19 and $14.78 respectively, a difference of $1.59 in favor of the Oat and Pea Hay Ration. Applying these results to a herd of thirty cows, the gain of the Oat and Pea Hay Ration over the Oat and Pea Feed and Straw Ration would amount to $23.85 per month. The results of these experiments indicate that Oat and Pea Hay will not only take the place of feeds to a large extent, but will also produce milk more economically.

IV. THE INDIVIDUAL ANIMALS.

The weights of the cows were taken at the beginning and close of each test. The following tabulation shows the weights at the close of the feeding tests, with the different rations :

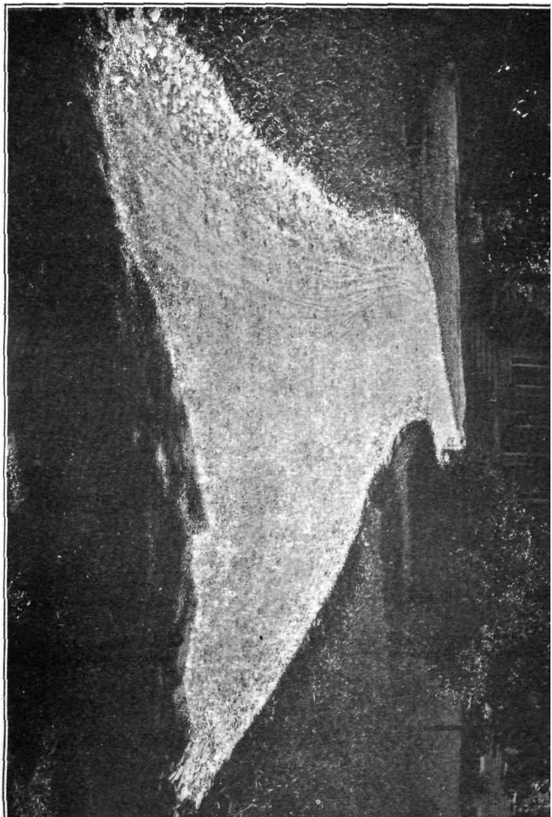
	OAT AND PEA FEED AND STRAW RATION.	OAT AND PEA HAY RATION.
Cow No. 1	960	985
Cow No. 2	1,015	1,000
Cow No. 3	1,070	1,080
Cow No. 4	970	975
Total	4,015	4,040
Average	1,004	1,010

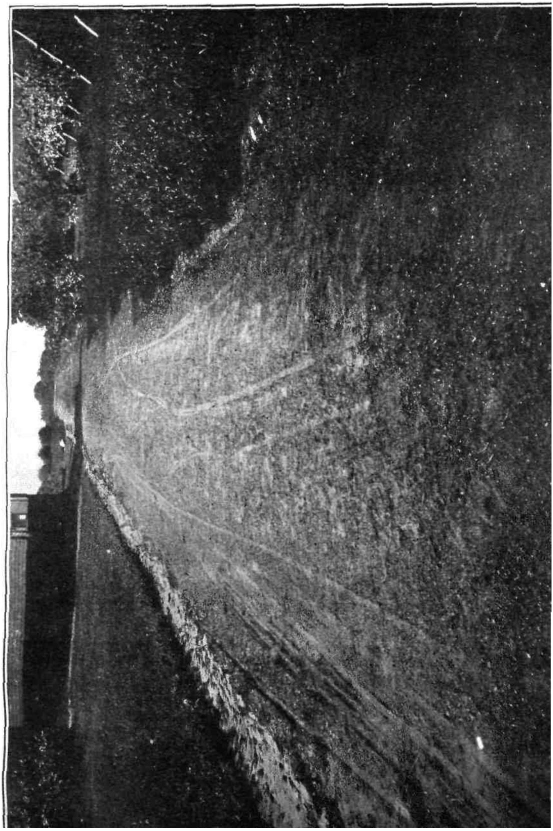
The above shows that cows Nos. 1, 3 and 4 made the largest gains on the Oat and Pea Hay Ration, while cow No. 2 gained more on the Feed Ration. The average gain for the cows, taken as a whole, shows six pounds in favor of the Oat and Pea Hay Ration. For experiments in growing oats and peas for grain and hay, see annual report for 1900, page 264.

Farm Roads.

The results of some experiments in building roads about the College Farm during the past three years may be of interest. A number of the factories in New Brunswick have a large supply of cinders to dispose of daily, and these can usually be obtained without expense, except cartage. This material was found valuable for road construction, and was used as a basis of three experiments.

I. Roads Made of Cinders.
II. Roads Made of Cinders and Gas Lime.
III. Roads Made of Cinders and Stone Lime.





I. ROADS MADE OF CINDERS.

Our first experience in road making was with cinders alone. The road-bed was made about fifteen feet wide, with side ditches sufficient to carry the water. The road was elevated in the center and sloped gradually toward the ditches, the thickness of the cinders in the center being from seven to nine inches. It was always dry, and stood the traffic well for a short time, but needed frequent repairs, owing to the fact that the cinders soon wore to a fine dust, allowing vehicles to cut through; furthermore, where cinders were used alone they did not resist the water, hence washed out readily.

II. ROADS MADE OF CINDERS AND GAS LIME.

This road was constructed in the same manner as the cinder road, and had considerable fall, as shown in Fig. 10. Gas lime, costing three cents per bushel, was mixed with the cinders, in the proportion of one to five (by bulk). A stream of water was allowed to run on the material while it was being mixed, to aid in packing. The mixture was then hauled to the road-bed and properly graded, care being taken to build the center high enough to shed water readily, after which it was rolled with a heavy roller until compact. This road has now been used three years, during which time it has been tested with all kinds of vehicles, heavy and light, and is in good condition to-day. No repairs have been made on it since it was built. There seems to be but one objection to this form of farm road, viz., the odor of the lime, which in damp weather is sometimes a little disagreeable. To obviate this objection we substituted stone lime for gas lime.

III. ROADS MADE OF CINDERS AND STONE LIME.

A road was constructed of cinders and stone lime (slacked), in the same manner as the road described above. The stone lime, however, was much more expensive, costing twelve cents per bushel. This road has been in use one year, and has stood the wear and tear equally as well as the gas lime; in fact, there does not seem to be much difference in the durability of the two roads. Where the road is not near any dwelling-house, the gas lime and cinders seem to answer all the requirements of a road for general farm traffic; but if the road is to be built near dwelling-houses, the stone lime will be preferable. Fig. 11 shows a road constructed of stone lime and cinders.

Description of the New Wing of the Dairy Barn

A gradual increase in the dairy herd, and the need of better quarters for the bulls and young stock, made it necessary to build an addition to the dairy barn last spring. The building is a frame structure (Figs. 12 and 13), 38 feet long by 32 feet wide, projecting at right angles from the main barn. It is one story high, the loft connecting with the second story of the main building, so that coarse foods can easily be transferred to the feeding floor of the new structure.

Main Floor.—The plan of the main floor is shown in Fig. 15. The ceiling is sheathed with matched lumber. The floor is made of Portland cement and coarse gravel (one part to eight), three inches thick. This is covered with a layer of Portland cement one inch thick, making the total thickness of the floor four inches. The manure gutters are sixteen inches wide and five inches deep. A slightly sloping surface in the stalls and gutters leads all water to the trap-doors, where it is conducted to cemented tanks below.

Mangers.—The mangers are built in and composed of the same material as the floor. A cross-section of the floor and mangers of the stable is shown in Fig. 16. The depth of the manger is three inches in the center, rounding up to the level of the floor. The width is one foot ten inches. It is used only as a feeding manger, the water being supplied in individual basins, which work automatically.

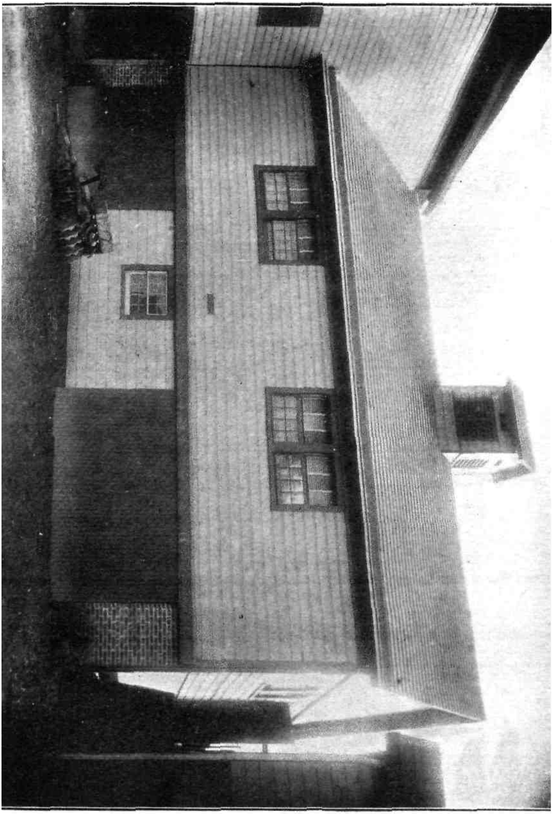
Stalls.—The stable contains thirteen stalls in two rows, which face each other, besides two special stalls for bulls and two box stalls, which may be used either for calves or for older animals. The feeding floor is seven feet wide. The two bull stalls, as well as the calf pens, are constructed of spruce posts, with frame-work of gas-pipe. (Fig. 14.)

The cows are fastened simply with a bow chain, attached on either side to a spruce post five inches in diameter. (Fig. 14.)

The bull stalls are connected with outside pens, 12 x 26 feet, where the animals are turned out every day for exercise.

Basement.—Under the barn is a basement divided into two rooms, one of which is used for storing wagons and farm tools, while the other contains the manure pits. These pits are frequently cleaned, but the cement floor above prevents odors from reaching the main floor; hence the arrangement is a sanitary one.

Ventilation.—The system of ventilation originated by Prof. King was used in this barn, and is shown in Fig. 16. A single ventilating flue (DE) rises above the roof of the barn, and is divided below the



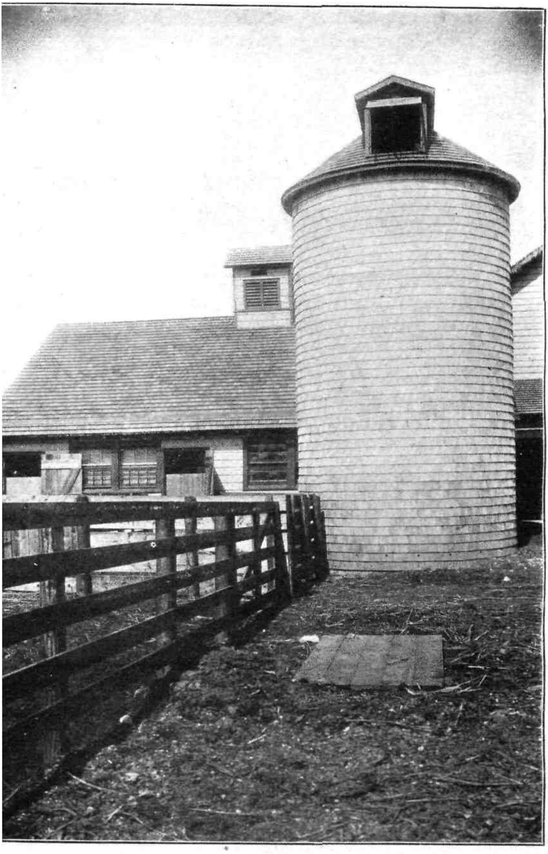


Fig. 13.

Rear View of Wing to Dairy Barn, showing Silo and outside Bull Pen.

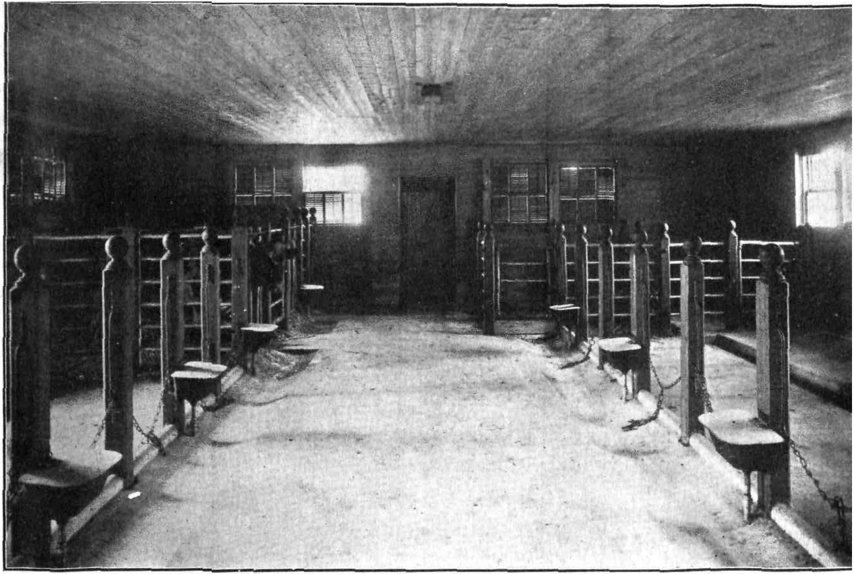


Fig. 14.
View of Interior of Wing to Dairy Barn.

roof into two arms (AAD), which terminate near the level of the stable floor (AA). These openings are provided with valves, which may be opened and closed at will. Two other ventilators are placed at BB, to be opened when the stable is too warm, but are provided with slides, to be closed at other times. C is a direct ventilator, leading into the main shaft and opening from the ceiling, to admit a current of warm air at all times to the main shaft, to help force the draught. The ventilating shafts are made of matched boards carefully placed, so that the flue is airtight. They are 6 x 16 inches and open into a chamber above the roof, three feet square.

The fresh air enters the stable on either side of the barn, as shown in the plan at FG, and the foul air is sent out at AA.

Silo.—The silo is circular in form, twelve feet inside diameter and thirty feet deep, with a brick foundation ten inches wide, carried six feet below the surface of the ground. The bottom is cemented and is five feet below the sills, which are made of 2 x 6 studding, cut on the slant of the radius of the silo circle, imbedded in mortar and toe-nailed together. The plates are made in the same way and spiked to studs, which are 2 x 6 and 18 inches apart. The lining consists of two thicknesses of half inch boards (the inner layer of pine and the outer one of spruce), with tarred paper between, painted inside with gas tar and gasoline, mixed in the proportion of 2 to 1. The siding consists of one layer of inch hemlock boards, nailed to braces between studs and covered with cedar shingles. Holes bored between each stud and covered with wire netting (Fig. 13) permit a circulation of air between the siding and lining, which aids the preservation of the latter. The structure is roofed as shown, with dormer window for filling and with ventilating cap, and is joined to the barn by a passage, also roofed. The silo is emptied by means of the "Schlichter method" of continuous opening, the silage dropping through a chute two feet square, upon the floor of the passage way, from which it is conveyed to the mangers of the animals.

Cost of Producing Milk.

Beginning April 1st, 1896, records have been kept of the cost of labor, the kind, amount and cost of foods eaten by the dairy herd, and the amount of milk produced by each cow. The cost of producing milk in previous years has been published in the annual reports. The cost for the year ending April 1st, 1901, is here reported. The herd averaged thirty cows.

TABLE IV.

The Kind, Amount and Cost of Foods for Thirty Cows for One Year, April 1st, 1900, to April 1st, 1901.

	Amount Fed. lbs.	Cost per ton.	Total.	
Wheat bran	34,000	$18 00	$288 00	
Dried brewers' grain	26,100	14 50	189 23	
Corn meal	15,000	21 00	157 50	
Linseed meal	1,800	28 00	25 20	
Cottonseed meal	9,000	27 00	121 50	
Pea meal	2,000	18 00	18 00	
Costs of feed				$799 43
Soiling Crops	360,000	$1 20	$216 00	
Silage	200,000	2 50	250 00	
Dried cornstalks	20,000	4 00	40 00	
Hay	30,000	5 34	80 10	
Roughage				$586 10
Total cost of food				1,385 53

Total cost of food	$1,385 53	
Cost per cow per day		12.65
Cost of feeds	799 43	
Cost per cow per day		7.30
Cost of roughage	586 10	
Cost per cow per day		5.35
Total yield of milk		89,851 quarts.
Average per cow per day		8.26 "
Cost of food per quart		1.54 cents.
Cost of feed per quart		.89 "
Cost of roughage per quart		.65 "

The cost of feeds represents what was actually paid. The cost of hay, cornstalks and soiling crops represents the actual cost of labor, seed and manure, the farm manure being charged at the rate of $1.50 per ton.

The average cost of the daily ration was 12.65 cents, of which 7.3 cents or 57.7 is due to purchased feed and 5.35 cents or 42.3 per cent. to the cost of farm crops. The total cost of producing milk, including the cost of labor, and the interest on and decrease in the value of the herd are given, the latter item being estimated.

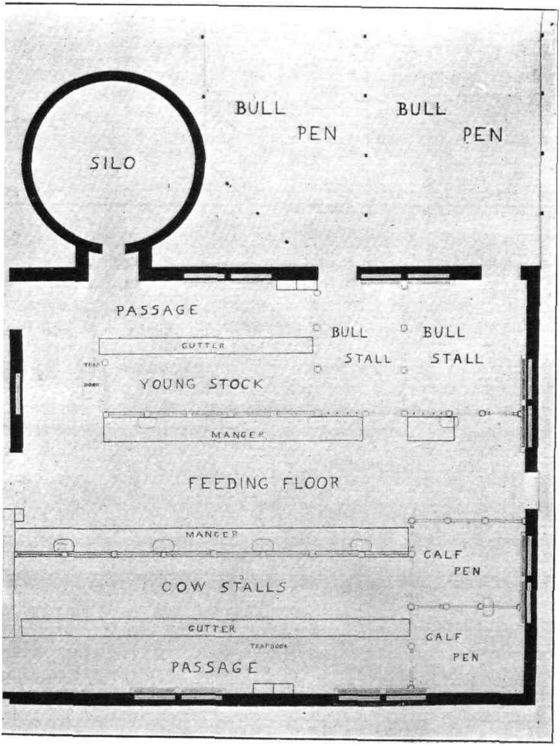
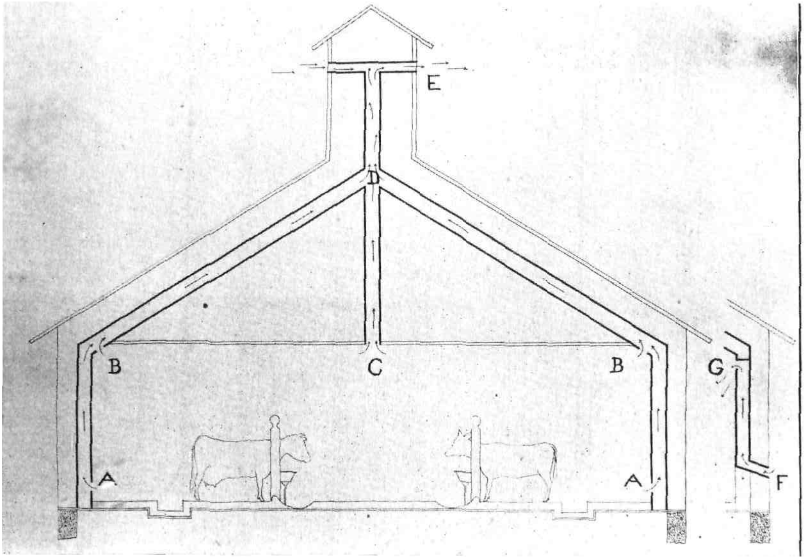


Fig. 15.
Showing Floor Plan of New Wing of Main Barn.


E
D
B
C
B
G
A
A
F

TOTAL COST OF PRODUCING MILK.

Foods as per statement		$1,385 53
Labor	$600 00	
Interest on value herd, at 5 per cent	60 00	
Decrease in value herd, at 5 per cent	60 00	
		720 00
Total		$2,105 53
Cost of food per quart of milk		1.54 cents.
Cost of labor and interest per quart of milk		.80 "
Total cost per quart		2.34 cents.

The average weights per quart of milk, as put up in bottles for delivery, was 2.18 pounds, hence the total weight of milk, 195,875 pounds, was equivalent to 89,851 quarts. The cost per hundred was, therefore, $1.07. At $1 per hundred, the price received in rural districts, the profits from the business, if any, must be in the *manure. In the calculation of the cost of farm foods, the manure* was charged at the rate of $1.50 per ton. The amount produced by the herd during the year was 330 tons. In selling milk at $1 per hundred, the receipts are $146.78 less than the expenses. Deducting this amount from the actual charges made for the manure, in the growing of the crop—$1.50 per ton—there remains $348.22, which represents the profits from thirty cows—an amount too small to make the business pay.

At three cents per quart, the price that could have been received at wholesale, the receipts would have amounted to $2,695.53. Deducting the cost of purchased feeds, labor and interest, and decrease in the value of the herd, amounting to $1,519.43, we have a balance of $1,176.10, which represents the value of the home-grown produce; or, in other words, at three cents per quart, the farm would sell its home-grown produce at profitable prices, namely, $2.45 for soiling crops, $5 for silage, $10.47 for hay and $8 per ton for dried corn stover, a gain on the crops over cost of production of $1.25 per ton for soiling crops, $2.50 for silage, $5.13 for hay and $4 for dried corn stover, besides an additional gain represented by 330 tons of manure. Looking at the question of profit from another standpoint, we will assume that the dairyman performs the work himself. Deducting, therefore, the item of labor, which amounted to $600, from the total cost of production ($2,105.53), we have a balance of $1,505.53. Dividing this amount by the total pounds of milk produced (195,875),

we find the cost per hundred 76.9 cents. The difference, therefore, between the cost and selling price of tbe milk represents the dairyman's profits from the business when he performs the work himself.

Assuming that the milk produced by the above thirty cows had been sold for $1 per hundred, a profit of 23.1 cents would have been realized in every hundred pounds, or a total of $452.47 for the year's production, besides the additional gain represented by 330 tons of manure. At three cents per quart, the profits would have amounted to $1,190, besides the additional gain re presented by the manure.

TABLE V.

Average Cost of Producing Milk for Five Years.

YEAR.	Number of cows.	MILK PRODUCED.		Average yield per cow.	COST PER COW PER DAY.			COST PER QUART OF MILK OF—			
		Pounds.	Quarts.		Feeds.	Roughage.	Total.	Feeds.	Roughage.	Labor and interest.	Total.
				lbs.	cts.	cts.	cts	cts.	cts.	cts	cts.
1896	23	141,517	64,9[illegible]6	6,153	4.99	6.61	11.6[illegible]	.646	.8[illegible]5	.99	2.49
1897	25	154,768	70,990	6,19[illegible]	5.06	6.38	11.44	.650	.82	.92	2.39
1898	25	172,726	79,23[illegible]	6,911	6.53	6.16	12.69	.750	.710	.82	2.28
1899	30	193,315	90,984	6,612	6.65	6.58	13.2[illegible]	.800	.790	.79	2.38
1900	30	195,875	89,851	6,529	7.3[illegible]	5.35	12.65	.890	.650	.80	2.34
Average		172,646	79,195	6,479	6.11	6.21	12.32	.747	.765	.86	2.38

The average production per year for the five years is shown to be 172,646 pounds, equivalent to 79,195 quarts. The average yield per cow was 6,479 pounds. The aver age cost of food per cow per day was 12.32 cents, of which 6.11, or 49.6 per cent., is due to purchased feeds, and 6.21, or 50.4 per cent., to the cost of farm crops. The average cost per quart of milk for the five years, including food, labor and interest and decrease in the value of the herd, is shown to be 2.38 cents.

SOILING CROP ROTATION.

The arrangement of crops, shown in Table VI., furnished a continnous supply of forage for the dairy herd from May 1st until November 1st, with the exception of two weeks in October, when mixed grasses were fed. The red clover on acre 1, the rye on acres 2, 7 and 8, the cow peas and sorghum on acre 3, the cow peas on acre 4, and the alfalfa on acre 10, were used for green manure. The total yield per acre for all crops in the year's rotation shows a profitable return. Leaving out of consideration the crops that were turned under, only one acre yielded less than ten tons, three acres yielded ten or more tons, and less than fifteen, six yielded over fifteen tons, and less than twenty, while three yielded over twenty tons.

A comparison of the amount of nutrients obtained per acre from the various combinations of crops, with that contained in clover hay, will give a better idea of their feeding value. For example, on acre No. 9 the protein is equivalent to that contained in 6.7 tons of clover hay, or in 5.8 tons of wheat bran. On acres Nos. 5 and 6 it is equivalent to that in 4.2 tons of clover bay; in Nos. 1, 2, 11 and 13, to three tons; Nos. 3, 4, 7, 8 and 12, to 2.3 tons, and in No. 10, to 1.1 tons.

In nearly every case, the proportion of carhohydrates exceeds the proportion contained in clover hay, thus making the nutrients comparable with this crop. The nutrients contained in three tons of wheat bran and corn meal respectively, are also added in the table for comparison.

In eight cases, three crops are grown upon an acre in a year, but with the exception of plots 5 and 6, the yield from but two crops is included, as the other crop was turned under. The actual yields, therefore, from six of the thirteen acres, was larger than is indicated.

TABLE VI.

Soiling Crops—Number, Kind and Acreage, 1901.

Number of acre.	CROP ROTATION.	Yield per acre.	NUTRIENTS. Protein.	Ether extract.	Fiber and N. free extract.
		tons.	lbs.	lbs.	lbs.
1	*Red Clover	......	......	......	......
	Oats and Peas	6.2	657.2	81.8	1,279.1
	Cow Peas and Kaffir Corn	12.2	334.3	134.2	3,294.0
	Total	18.4	991.5	216.0	4,573.1
2	*Rye	......	......	......	......
	Oats and Peas	6.2	657.2	81.8	1,279.1
	Cow Peas and Kaffir Corn	12.2	334.3	134.2	3,294.0
	Total	18 4	991.5	216.0	4,573.1
3	Wheat	5.2	288.6	93.6	1,860.6
	Barnyard Millet	11.6	373.5	204.2	4,932.3
	*Cow Peas and Sorghum	......	......	......	......
	Total	16.8	662.1	297.8	6,792.9
4	Wheat	5.2	288.6	93.6	1,860.6
	Barnyard Millet	11.6	373.5	204.2	4,932.3
	*Cow Peas	......	......	......	......
	Total	16.8	662.1	297.8	6,792.9
5	Rye	9.6	498.2	115.2	3,513.6
	Soy Beans	8.8	501.6	96.8	2,398.9
	Barley	2.6	140.4	31.2	821.6
	Total	21.0	1,140.2	243.2	6,734.1
6	Rye	9.6	498.2	115.2	3,513.6
	Cow Peas	10.5	604.8	161.7	2,100.0
	Barley	2.6	140.4	31.2	821.6
	Total	22.7	1,243.4	308.1	6,435.2
7	*Rye	......	......	......	......
	Oats and Peas	4.1	434.6	54.1	845.8
	Pearl Millet	9.2	207.9	68.1	2,526.3
	Total	13.3	642.5	122.2	3,372.1
8	*Rye	......	......	......	......
	Oats and Peas	4.1	434.6	54.1	845.8
	Pearl Millet	11.0	248.6	68.1	3,020.6
	Total	15.1	683.2	122.2	3,866.4
9	Alfalfa	21.7	1,803.3	384.1	7,011.8
	Total	21.7	1,803.3	384.1	7,011.8
10	*Alfalfa	......	......	......	......
	White Flint Corn	9.1	300.3	112.8	3,011.2
	Total	9.1	300.3	112.8	3,011.2
11	Oats and Peas	3.3	349.8	43.6	680.8
	Cow Peas	8.0	460.8	123.2	1,600.0
	Total	11.3	810.6	166.8	2,280.8

* Used for green manure.

TABLE VI—Continued.

Soiling Crops—Number, Kind and Acreage, 1901.

Number of acre.	CROP ROTATION.	Yield per acre.	Nutrients. Protein.	Nutrients. Ether extract.	Nutrients. Fiber and N. free extract.
		tons.	lbs.	lbs.	lbs.
12	Rye	4.7	243.9	56.4	1,720.0
	Sorghum	14.0	380.8	142.8	3,290 0
	Total	18.7	624.7	199.2	5,010.0
13—	Mixed Grasses	10.2	958.8	244.8	4,284.0
	Total	10.2	958.8	244.8	4,284.0
	Four tons clover hay contains		1,080	264	5,040
	Three " " " "		810	198	3,780
	Two " " " "		540	132	2,520
	Three tons wheat bran contains		924	246	3,240
	Three tons corn meal "		558	228	4,200

The Dairy Business in Relation to Soil Exhaustion.

The following table shows the amount of fertilizing elements contained in the feeds purchased, and in the milk produced, by a herd of 23 cows in 1896, 25 cows in the years 1897 and 1898, and 30 cows in 1899 and 1900 :

TABLE VII.

KINDS.	AMOUNT.					NITROGEN.					PHOSPHORIC ACID.					POTASH.				
	1896.	1897.	1898.	1899.	1900.	1896.	1897.	1898.	1899.	1900.	1896.	1897.	1898.	1899.	1900.	1896.	1897.	1898.	1899.	1900.
	tons.	tons.	tons.	tons.	tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Wheat Bran	9.40	12.50	14.50	15.85	17.00	460	612	710	777	833	545	725	841	919	986	301	402	464	507	544
Dried Brewers' Grains	9.20	8.15	10.25	13.75	13.05	662	587	838	990	940	202	179	226	303	287	15	13	17	22	21
Corn Meal	6.10	3.30	5.00	7.05	7.50	201	109	165	233	248	85	46	70	99	105	49	26	40	56	60
Linseed Meal	3.55	4.45	3.50	1.05	.90	377	473	372	111	95	126	158	124	38	32	97	121	96	29	24
Cottonseed Meal	......	......	......	1.75	4.50	......	......	......	238	612	......	......	......	106	275	......	......	......	66	171
Rice Meal	......	......	1.75	2.70	......	......	......	69	105	......	......	......	94	145	......	......	......	25	39	......
Pea Meal	......	......	......	......	1.00	......	......	......	......	82	......	......	......	......	16	......	......	......	......	20
Buckwheat Feed	......	......	.50	1.60	......	......	......	36	29	......	......	......	18	58	......	......	......	13	42	......
Total or gain in feeds	......	......	......	......	......	1,700	1,781	2,190	2,483	2,760	958	1,108	1,373	1,668	1,701	462	562	655	761	840
Sold in Milk	70.86	77.38	86.36	99.17	97.94	849	927	1,036	1,190	1,173	318	347	389	446	440	248	271	302	347	343
Gain to farm	......	......	......	......	......	851	854	1,154	1,293	1,587	640	761	984	1,222	1,261	214	291	353	424	497
Total gain in five years	......	......	......	......	......	5,739					4,868					1,779				

The above table shows a decided gain to the Farm in fertility elements during all five years. The total gain is equivalent in nitrogen and phosphoric acid to that contained, respectively, in 18.5 tons of nitrate of soda and 20.4 tons of acid phosphate, and in potash to that contained in 1.78 tons of high-grade muriate of potash. It is not affirmed that the constituents contained in the manure are equal in agricultural value to those contained in the fertilizers mentioned, or that, even under the best conditions of care and application, they could all be used by the plants, but, because the manure contains all the constituents and is well adapted for most crops, the general farmer is, as a rule, able to get as good returns from it in proportion to constituents contained as from products containing the same constituents in more available forms.

The tabulation shows that if all the milk sold from the Farm was obtained from foods grown on the Farm, the exhaustion of nitrogen would be in greater proportion than the mineral elements, and that when this is a practice, it is necessary to apply nitrogenous fertilizers in order to maintain the fertility. If manure is well cared for and used properly, it is more economical to purchase the nitrogen in the form of feeding stuff, whose whole cost is returned in the increased product resulting from the use of the well-balanced rations.

RECORDS OF THE DAIRY HERD, APRIL 1ST, 1900, TO APRIL 1ST, 1901.

Beginning April 1st, 1896, complete records have been kept of the dairy herd, including the yield and composition of the milk of individual animals. The records have been published annually in the Station Reports.

The herd consists largely of grade animals; three Guernseys, four Ayrshires and one Holstein are pure bred. Twenty-six animals remained in the herd throughout the entire year, and their records are given in the tabulation. Many of the cows giving the lower records have been valuable animals in past years, but have now ceased to be profitable, and will be disposed of during the present year. The average, however, for the herd is 6,545 pounds.

As already shown, under "Cost of Producing Milk," the foods consumed were only such as to provide a sufficient and well-balanced ration. Soiling crops were fed for six months and silage the remainder of the year. In connection with the weight of the milk which was taken from each animal daily, the product from each cow was sampled and analyzed once each week. The accompanying table shows the monthly yield of milk and its composition, as well as the total yield per cow of milk, of fat and of butter.

The butter equivalent is derived from the fat by adding one-sixth.

TABLE VIII.

Record of the Dairy Herd.

Number of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. of fat.	Total fat.	Equivalent to butter.
1	Pounds of Milk......	523.1	589.2	553.6	460.3	398.3	230.2	459.9	544.0	581.2	682.0	538.7	605.5	6,066.0	4.0	240.93	281.09
	Per Cent. of Fat......	3.9	4.0	3.7	3.8	4.3	4.4	4.1	4.1	3.9	4.0	3.9	3.9	....			
2	Pounds of Milk......	1,361.4	1,275.9	1,181.2	917.4	869.9	824.2	758.0	504.8	378.3	220.1	....	123.5	8,351.7	4.2	348.90	407.05
	Per Cent. of Fat......	4.1	4.2	3.9	4.0	4.2	4.2	4.4	4.5	4.2	4.6	....	4.8	....			
3	Pounds of Milk......	571.1	315.6	84.3	85.5	1,160.4	1,099.7	1,034.7	836.1	830.8	892.2	795.0	860.9	8,516.3	4.1	349.20	407.40
	Per Cent. of Fat......	4.9	5.1	5.1	5.1	3.8	3.5	3.8	3.9	4.2	4.2	4.2	40.5	....			
4	Pounds of Milk......	1,171.4	1,067.6	939.3	821.4	763.4	731.3	610.1	533.9	390.0	35.4	....	....	7,063.8	4.3	302.01	352.35
	Per Cent. of Fat......	4.1	4.3	3.9	4.1	4.4	4.2	4.6	4.7	4.8	4.8	....	....	....			
5	Pounds of Milk......	828.6	943.8	865.1	464.8	....	....	....	214.2	1,005.9	1,066.4	977.0	994.2	7,360.0	4.1	305.08	355.93
	Per Cent. of Fat......	4.0	4.1	3.8	4.4	....	....	....	4.7	4.7	4.1	4.0	4.0	....			
6	Pounds of Milk......	678.2	782.2	735.2	720.2	719.2	685.2	644.3	626.9	649.0	695.5	575.3	642.8	8,014.0	4.2	332.70	388.15
	Per Cent. of F-t......	4.3	4.3	4.1	3.8	4.0	3.7	4.3	4.4	3.9	4.2	4.4	4.5	....			
7	Pounds of Milk......	....	....	....	1,228.7	1,299.5	1,206.3	993.4	885.7	931.7	903.7	595.9	360.8	8,300.7	3.9	321.66	375.27
	Per Cent. of Fat......	....	....	....	3.6	3.6	3.6	3.8	4.1	4.0	4.0	4.3	4.8	....			

TABLE VIII.

Record of the Dairy Herd—Continued.

Number of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. fat.	Total fat.	Equivalent to butter.
8	Pounds of Milk.....	839.4	944.3	885.6	729.2	594.4	328.1	86.8	....	332.2	1,591.5	1,301.4	1,373.7	9,006.6	3.5	319.29	372.51
	Per Cent. of Fat.....	3.5	3.4	3.3	3.6	4.1	3.7	4.1	....	3.5	3.5	3.6	3.5	....			
9	Pounds of Milk.....	593.7	579.5	479.0	602.4	666.8	639.3	540.7	553.3	588.9	505.5	510.9	563.1	6,818.1	4.3	294.75	343.88
	Per Cent. of Fat.....	4.5	4.5	3.9	4.2	3.8	4.0	4.5	4.2	4.5	4.3	4.4	4.7	....			
10	Pounds of Milk. ...	536.6	458.5	422.5	644.0	656.6	592.1	600.9	601.5	537.2	438.0	366.3	418.0	6,267.2	4.6	288.62	336.72
	Per Cent. of Fat.....	4.8	5.3	4.8	4.2	4.1	4.4	4.7	4.4	4.6	4.8	4.8	4.9	....			
11	Pounds of Milk.....	803.0	838.5	788.6	688.4	677.9	604.9	308.8	....	....	....	....	479.4	5,189.5	4.4	229.12	267.31
	Per Cent. of Fat.....	4.7	4.7	4.2	5.1	3.9	4.4	5.8	....	....	....	....	4.1	....			
12	Pounds of Milk.....	420.4	462.7	399.5	825.4	547.8	549.5	539.4	568.6	608.7	543.6	442.0	444.7	5,852.3	4.7	272.14	317.50
	Per Cent. of Fat.....	4.9	4.7	4.8	4.7	4.4	4.1	4.2	5.1	4.9	4.7	4.7	4.7	....			
13	Pounds of Milk.....	487.3	580.2	558.4	480.0	412.9	295.5	47.9	....	874.6	1,084.4	991.1	1,083.9	6,841.2	4.5	309.59	361.19
	Per Cent. of Fat.....	4.5	4.3	4.7	4.5	4.9	5.2	6.1	....	4.8	4.5	4.4	3.8	....			
14	Pounds of Milk.....	646.2	764.7	702.4	589.9	565.4	537.5	459.5	229.5	....	....	....	....	4,495.1	4.8	215.61	251.55
	Per Cent. of Fat.....	4.5	4.8	4.8	4.7	4.7	5.1	5.8	5.9	....	....	....	....	....			

TABLE VIII.

Record of the Dairy Herd—Continued.

Number of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. fat.	Total fat.	Equivalent to butter.
15	Pounds of Milk.....	372.0	456.3	418.9	212.2	379.8	465.6	484.3	418.3	408.8	375.0	384.6	304.1	4,549.9	4.5	205.99	240.32
	Per Cent. of Fat....	4.5	4.8	4.6	4.9	4.4	4.1	4.0	4.6	4.3	4.6	5.0	5.0	....			
16	Pounds of Milk.....	....	....	....	414.7	895.7	899.6	860.8	785.6	802.5	723.7	659.6	636.3	6,660.5	4.5	298.72	348.51
	Per Cent. of Fat.....	....	....	....	3.6	4.2	4.1	4.4	4.8	4.7	4.6	4.9	4.9	....			
17	Pounds of Milk.....	470.3	511.1	446.5	406.9	405.6	340.4	249.8	77.3	....	561.1	640.7	855.3	5,164.5	5.3	275.70	321.65
	Per Cent. of Fat.....	5.6	5.6	5.5	5.5	4.3	6.0	6.1	6.9	....	5.0	5.2	5.1	....			
18	Pounds of Milk.....	1,324.3	1,314.9	1,115.5	886.2	792.0	770.9	637.6	391.4	55.6	....	....	1,152.7	8,444.1	3.9	331.20	386.40
	Per Cent of Fat.....	3.6	3.9	3.8	3.9	4.1	4.1	4.3	4.7	4.7	....	....	3.7	....			
19	Pounds of Milk.....	387.5	412.5	352.2	292.8	385.5	321.7	252.6	70.5	....	254.1	733.9	597.6	4,010.9	4.5	179.15	209.01
	Per Cent. of Fat.....	4.4	4.6	4.3	4.2	4.3	4.5	5.0	6.3	....	4.0	4.5	4.5	....			
20	Pounds of Milk.....	....	....	....	....	31.8	495.3	741.1	594.6	641.8	599.0	503.7	521.1	4,128.4	3.9	160.72	187.51
	Per Cent. of Fat.....	....	....	....	....	3.6	3.6	3.7	4.0	4.0	3.9	4.0	4.1	....			
21	Pounds of Milk.....	506.6	526.5	485.5	320.3	217.9	629.1	566.5	497.4	500.2	439.6	381.4	405.6	5,426.6	5.2	283.25	380.46
	Per Cent. of Fat.....	4.9	5.5	4.9	5.8	5.4	5.2	5.0	5.0	5.1	5.7	5.3	5.2	....			

TABLE VIII.

Record of the Dairy Herd—Continued.

Number of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. fat.	Total fat.	Equivalent to butter.
22	Pounds of Milk.....	....	....	659.8	809.6	755.6	573.2	512.8	474.1	442.6	359.9	216.7	331.2	5,165.0	5.2	267.11	311.63
	Per Cent. of Fat.....	....	....	4.7	4.8	5.0	5.0	5.1	5.7	5.1	5.9	5.8	5.9	....			
23	Pounds of Milk	720.8	696.9	586.5	48.5	....	....	....	871.0	1,221.8	1,026.8	857.0	899.0	6,878.3	3.9	266.99	311.49
	Per Cent. of Fat.....	3.8	4.0	4.0	4.0	....	....	....	3.9	3.6	4.0	4.1	3.8	....			
24	Pounds of Milk	316.1	88.5	....	....	....	726.4	877.5	695.9	667.7	601.7	566.8	508.2	4,988.8	4.5	223.43	260.67
	Per Cent. of Fat.....	4.9	5.5	....	....	....	4.8	4.4	4.5	4.4	4.4	4.3	4.1	....			
25	Pounds of Milk.....	472.0	535.8	432.6	181.9	....	....	198.4	1,062.8	993.5	884.3	835.4	911.0	6,496.7	4.5	292.85	341.66
	Per Cent. of Fat.....	4.9	4.7	4.7	5.3	....	....	4.8	4.5	4.5	4.4	4.3	4.3	....			
26	Pounds of Milk.....	1,153.2	1,160.4	1,078.5	911.9	889.0	861.6	802.0	623.6	656.5	721.2	629.1	632.2	10,119.2	3.8	387.83	452.47
	Per Cent. of Fat.....	3.6	3.6	3.4	3.6	3.5	3.6	4.0	4.5	4.3	4.2	4.1	4.5	....			
	Average.	....	....	....	....	....	....	....	....	....	....	....	....	6,545.0	4.29	280.87	327.68

In a herd of grade cows representing several breeds, it is natural that there should be a wide variation both in the yield and composition of the milk produced by the individual animals. While there are two distinct classes of dairy cows, viz., milk producers and butter producers, there are also many animals of mixed breeding which combine these two characteristics in a remarkable degree. This point is clearly brought out in the following tabulation: 1. Yields of milk. 2. Yields of butter. 3. Yields of milk and butter from animals which combine in a marked degree the qualities of both milk and butter production.

1. Yields of Milk.

5 cows	an average of	more than	4,000 lbs.	and less than	5,000 lbs.
5 "	"	"	5,000 "	"	6,000 "
7 "	"	"	6,000 "	"	7,000 "
2 "	"	"	7,000 "	"	8,000 "
5 "	"	"	8,000 "	"	9,000 "
1 cow	"	"	9,000 "	"	10,000 "
1 "	"	"	10,000 "		

The best cow produced	10,119.2 lbs.
The poorest cow produced	4,010.9 "
Difference between the highest and the lowest	6,108 3 lbs.
The average per cow was	6,545.0 "

2. Yields of Butter.

1 cow	an average of	more than	150 lbs.	and less than	200 lbs.
2 cows	"	"	200 "	"	250 "
4 "	"	"	250 "	"	300 "
9 "	"	"	300 "	"	350 "
7 "	"	"	350 "	"	400 "
2 "	"	"	400 "	"	450 "
1 cow	"	"	450 "		

The best cow produced	452 lbs.
The poorest cow produced	187 "
Difference between the highest and lowest	265 lbs.
The average per cow was	327 "

3. Yield of Milk and Butter.

From animals which combine in a marked degree the qualities of both milk and butter production.

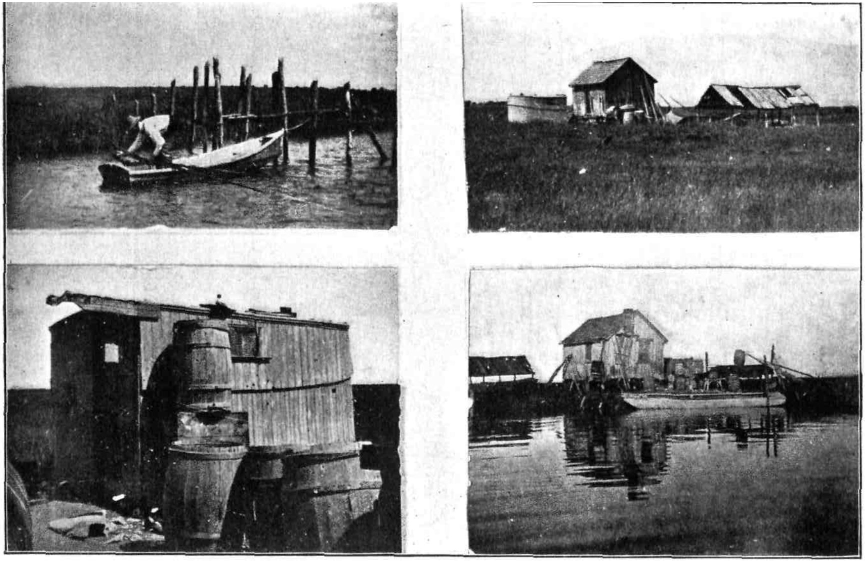
	Breed	Yield of Milk. Lbs.	Yield of Butter. Lbs.
Cow No. 2	Grade Jersey	8,351	407
" 3	" Holstein	8,516	407
" 4	" Shorthorn	7,063	352
" 5	" Jersey	7,360	355
" 6	" Holstein	8,014	388
" 7	" "	8,300	375
" 8	" "	9,006	372
" 18	" "	8,444	386
" 26	Pure Bred Holstein	10,119	452

The range in percentage of butter fat was from 3.5 per cent. to 5.2 per cent., with an average of 4.29 per cent. It has been shown that the cost of rations per cow per day was 12.65 cts. or a total of $46.17 per year. Following the same line of comparison, the advantages of the better cows are strongly shown in the following tabulation :

	At 1 cent per lb.	At 3 cents per qt.	Cost of food.	Gain over Food. At 1 cent per lb.	Gain over Food. At 3 cents per qt.
Average value of product of 16 cows yielding more than 6,000 lbs. of milk	$75 75	$104 25	$46 17	$29 58	$58 08
Average value of product of the 10 cows yielding less than 6,000 lbs. of milk	48 97	67 38	46 17	2 80	21 21
Value of product of the average cow	65 45	90 06	46 17	19 28	43 89

At one cent per pound, the yield of the 16 cows producing more than 6,000 pounds of milk is sufficient to pay for their food and $29.58, besides manure, for care and profit, while the average yield of the 10 cows producing less than 6,000 pounds of milk is sufficient to pay for their feed and only $2.80, besides manure, for care and profit—a difference of $26.78 in favor of the better cows. At 3 cents per quart, the returns of the cows yielding over 6,000 pounds of milk, over cost of feed, are increased to $58.08, while for the cows yielding less than 6,000 pounds of milk, they are increased to $21.21, or less than one-half of those of the better cows at one cent per pound.

REPORT OF BIOLOGIST.



Oyster Experiment Station, near Tuckerton, N. J.

EXPLANATION OF FRONTISPIECE.

OYSTER EXPERIMENT STATION, NEAR TUCKERTON, N. J.

This plate shows four photographic views of the Mott Oyster Station and its environments They are, respectively, from left to right (upper views first):

1. Mr. Mott securing oysters for experimental purposes from the creek.
2. View of the buildings from the east, showing from left to right the laboratory, the "hotel bivalve" and the breeding shed.
3. View of laboratory from west, nearer view.
4. View of buildings from west, looking across the creek.

REPORT OF BIOLOGIST.

SCIENTIFIC STUDIES OF OYSTER PROPAGATION.

[THE FERTILIZATION OF THE EGG.]

Sec. 1. The Oyster Experiment Station.

The Legislature of the State of New Jersey, during the session of 1901, passed acts appropriating more than $25,000 for the protection of the oyster industry and for increasing natural oyster seed. Of greater importance was the passage of an act providing for the leasing of certain oyster planting grounds in Delaware bay at twenty-cents per acre.

But the legislation which, from the standpoint of science and the history of oyster culture, was the most significant that was enacted by this legislature was the passage of an act providing for the establishment of one or more stations for the "scientific investigation of oyster propagation," to-wit (Chapter 99, Laws of New Jersey, 1901) :

"Be it enacted by the Senate and General Assembly of the State of New Jersey :

"1. The director of the New Jersey Agricultural College Experiment Station at New Brunswick is hereby authorized to establish and maintain one or more stations for the scientific investigation of oyster propagation, said station or stations to be situate at some point or points in the oyster growing sections of this state. The amount authorized to be expended under the provisions of this act shall not exceed the sum of two hundred dollars in any one year; *provided*, that no moneys shall be drawn from the treasury for the purposes of this act until the same shall have been specifically appropriated according to law.

"2. This act shall take effect immediately.

"Approved March 21, 1901."

The act (see chapter 210, paragraph 88) making appropriation for this purpose, approved March 22d, 1901, did not go into effect until

November 1st, 1901, *i. e.*, after the oyster breeding season for said year was ended. Nevertheless, it was thought best not to lose the first season, which gave opportunities for carrying into effect the provisions of a law already in force ; and so at the opening of the spawning season, in June, the Biologist of the Station advised Mr. Geo. A. Mott, of Tuckerton, N. J., as to the appliances required for Oyster Experiment Station No. 1, or as it shall hereafter be called, the "Mott Oyster Experiment Station."

This, the first Station established under the law, was thus named by the Biologist, because of its situation upon Mr. Mott's property, because of Mr. Mott's share in its erection and in the work carried on there, and because of his share in securing the passage of the act creating such stations.

The situation, so far as conditions necessary to oyster growth are concerned, is unexcelled, if not unequaled, by any other site within the State known to the Biologist. But successful experimenting in oyster culture, guided by microscopical studies, cannot be prosecuted without the aid of a practical oysterman, who not only secures the right sorts of oysters, but who gives the practical data which theory must deal with. The aid extended the investigator, through Mr. Mr. Mott's enthusiastic faith in the ultimate success and value of these researches, and his untiring, skillful and self-sacrificing labors in preparing the field apparatus, have been invaluable.

The small appropriation asked for did not contemplate any wages for the cook and necessary helper, who must be present at this Station whenever the scientist is at work, much less any salary for the investigator himself. As Mr. Mott offered his services free, and these investigations being brought under the regular work of the Biologist of the Agricultural Experiment Station, the limited appropriation was available for paying traveling expenses of the investigator, wages of laborers for digging and construction, expenses for lumber and other materials, and cost of provisions and utensils. The microscopical apparatus was supplied from the Biological Department at New Brunswick.

This appropriation, economically spent, served to pay for the maintenance of the Mott Station for six weeks of occupancy ; and in addition, by repairing a dilapidated oyster-house and utilizing the top of a yacht's cabin, there have been "established" two buildings, one used for an oyster laboratory and the other for combined kitchen, dining-room and dormitory, called "Hotel Bivalve." See frontispiece of the report of the Biologist.

Besides the buildings and their equipment, two rather extensive claires were constructed (one under roof), and a large floating tank and a garvey were prepared, which were used to receive the oyster fry when they were ready to "plant."

Should future legislatures renew the aunual appropriation, it will become possible to establish oyster experiment stations at other points; but so long as the present Station offers sufficient facilities, it can advantageously be used in discovering the fundamental principles that underlie artificial oyster propagation, which would then be applied and supplemented at such secondary stations.

It must, however, be patent that, with the small appropriation we had, the equipment of the Mott Station is crude and incomplete. In spite of this fact, the most pressing need of the immediate future is a "house-boat" or floating laboratory, which can be constructed in a simple way for a moderate sum, and will serve with greater convenience both as hotel and laboratory, with the added advantage of portability, enabling the investigator to reach parts that are now practically inaccessible to a laboratory on land to study the oyster propagation upon the natural beds as a guide to artificial propagation. Such a laboratory would take the place of several stations upon all the part of tbe coast that can be reached with such a hoat. This matter is commended to the attention of those interested.

Sec. 2. Work of the Season at Mott Station in General.

In a subsequent section we give, in chronological order, a journal of the scientific experiments conducted at the Mott Oyster Experiment Station dnring the summer of 1901. In the present section we shall take a general glance at the work and its results.

Work began June 21st, and on that day, as on each subsequent day when the Biologist was at this Station, one or more experiments were made in raising oysters from the spawn. The spawn of American oysters, it must be remembered, does not consist of young oyster fry, as is the case with the oyster on the European Atlantic shore. On our side of the ocean the oysters are of two sexes. When the eggs (or "roe") of the female and the sperms (or "milt") of the male have become "ripe," the very numerous and very small particles composing this "spawn" are shed into the water by the individual oysters. It is in the water that the eggs become fertilized by the sperms, and then undergo a development which transforms them, first, into free-swimming "fry," and later this "fry" settles as

nearly-invisible "spats" upon shells, etc. The details of this development were treated in our report last year, and subsequent sections of the present report treat the subject still more specifically.

In artificial oyster propagation it is necessary to work in the spawning season, procuring the oysters absolutely fresh, and after opening them to decide, first, by the general appearance, whether they are "ripe," and secondly, by microscopical examination, to determine the "sex" of the spawn. Then the "male spawn" is put into a tumbler of water and the eggs are added, the whole being kept stirred so that the eggs shall not settle in the bottom. After ten minutes or so the dishes are set aside, to allow the eggs to settle, and after about twenty minutes the milky fluid containing sperms and light eggs and other *debris* is poured off, and new water is added; then the washing of the eggs may be repeated, to "clean" them still more. Such an operation is termed "fertilizing" the eggs, and all the eggs that have been in proper condition to receive a sperm will soon begin developing. This development can be watched under the microscope. After about an hour, more, or less, according to the temperature, the eggs, which, as they came from the oyster, were irregular or elongated in shape, and soon after fertilization became "round" (*i. e.*, spherical), will now be seen to have one or more buds on them, as if little eggs were attached to larger ones. Each developing egg pinches off a part of itself, but this part remains sticking to the egg. The part pinched off in turn becomes constricted into two smaller globes, and new buds are pinched off along side, so that after a while the egg has the shape of a little mulberry. See Figs. 1, 58, 94, 96, 105 to 116.

After five to eight hours this mulberry mass begins to spin around (rotate) and finally to swim; and then, as all the eggs that cannot develop remain lying on the bottom of the dish and undergo decomposition, the water containing the lively embryos or "fry" is poured off and the sediment is thrown away.

These operations must be repeated with every lot of spawn fertilized in order to obtain a lot of fry. The fry, after about five days, develop a two-valved shell, and then they seek a place to settle down on. They must be put into a place where the water contains very fine particles of food, and clean shells on which to "set," in order to attain further development. The little swimming fry are as small as the finest dust, and have but little power to swim. They are carried away by the slightest current, and it is evident that if we desire

to keep them and raise them, they must be put into some enclosure where they cannot get out.

The enclosures we experimented with were two in number. In the first place a garvey (boat) was half filled with sea water and floated in the creek near the oyster station. In the second place, a tank 16 by 4 feet, made of pine planks, was also half filled and floated in a claire under a shed. The water could freely run in and out of the claire with the tide. The tank was so made that water could enter and leave it without losing the fry. This was effected by making the ends of the tanks double, with a wide space between, filled with fine sand. The double ends were perforated with augur-holes, and the sand was retained by lining the perforated boards with cloth. The water that entered the tank was free from mud and small enemies that might eat the fry. It was also, unfortunately, free from oyster food. It is needful that the water in such a tank shall stand quite a while, to allow the microscopic plants to breed. The fact that the tank was made of "new" pine planks, probahly, also influenced the water so that it could not support oyster food.

Only one little spat developed on the shells placed in this tank, and that grew so slowly that for a time it was thought to be dead. This tank will likely have become properly seasoned by next summer, and not until then can its efficiency be known.

On the other hand, the water in the garvey was unchanged from day to day, and it became "thick" with microscopic plants, though not all of these could be used as oyster food. Several spat were found attached to the shells in this receptacle, and they grew very well.

The tank and garvey had received each week the spawn-lots that had been started during the week, so that it is likely that these spat were artificially raised. But, unfortunately, two serious occurrences prevented us from properly experimenting with these tanks. First of all, only the earlier spawn lots raised in our dishes had the proper vigor to reach the shell stage, and these tanks were not ready to receive them until it was too late. It was a curious fact that, though nearly thirty lots of spawn were artificially started after these tanks were ready, they all failed to reach the shell stage. About a dozen of these lots were planted in these reservoirs before they reached the shell stage, because they were dying in the dishes wherein they were started. It was at first thought that death was due to the fact that the life conditions in the dishes were unfavorahle, therefore they were transplanted into what were supposed to be more favorable

quarters. But a careful study of all the data of the summer's experiments has convinced the biologist that these fry could not live under any conditions. Possibly one or two out of a million might live, but for practical purposes they were an "enfeebled folk."

The second serious occurrence which prevents our concluding that these spat were artificially raised was the fact that at one of the heaviest tides both tank and garvey became so much tilted that some of the outside water ran in over the top. Now, this outside water, in all probability, contained some fry, as the creek is lined with oysters. No natural "set" regularly occurs here, and that fact may be due to two causes—first, that the "plants" are largely southern oysters, which, though they become very "spawny," probably do not produce viable embryos in northern waters, and secondly, the water is so full of sediment there is no clean surface for the fry to fasten to. At any rate, the fresh poles put under the tank to hold it up when the tide runs ont received a "set." This "set" may, of course, have come from oysters artificially propagated and poured into the creek, but any such accessions are small, compared with what nature can produce, if, as is likely, most all the planted oysters spawn naturally.

Even if the spats found in the tanks came from artificially-fertilized oyster spawn, the fact that millions of such spawn were placed in the tank and only one developed, would seem quite discouraging, unless we refer the poor result to the fact that the artificial fry lacked strength to survive.

The work of the summer is not to be judged by the results of the tank experiments by themselves. These are but a link in a series of results, all pointing to one truth, viz., that we have been under the domination of a wrong theory during these past years. We have tacitly assumed that, when we fertilized an oyster egg and it seemed to develop normally to the fry stage, it would continue to live to adult age if no enemy killed it, and provided it were given proper food and water. Nothing can be further from the truth. If there is one teaching of all our oyster experiments that stands out boldly above any others, it is this, viz., that when we have a lot of normally developing oyster eggs, that fact is no guarantee that these eggs will live the limit of oyster life. Whatever may be the usual death rate among naturally fertilized eggs, it is certain that artificially propagated oysters show an extraordinary "infant mortality." It is known that only one of a million (or more) of oyster fry ever reaches adult age on a natural oyster bed, and that fact has been

explained by assuming that the young were eaten or failed to find a lodging place. But if in artificial fertilization an egg may be fertilized and then die at various stages in the development, does not that show that similar cases must occur under natural conditions?

There are certain years when no set is observed, and there are certain years when the spawn of oysters is ill adapted even for experimental fertilization. There have been climatic conditions, or some similar universal influences, at work that have operated to produce eggs of inferior quality. Fewer eggs are spawned; those spawned are not viable even when fertilized, or the amount of spawn in the water fall below the limit needed for successful impregnation.

We showed last year that "if a certain bulk of eggs be diluted *twenty-five times, and a bulk of sperms, one five-thousandth as great,* be added, the eggs will fail to be fertilized. The best results occur when the eggs are diluted one thousand times and a bulk of sperms one twenty-fifth of that of the eggs be added."

A volume the size of an oyster egg can contain approximately 3,000 sperms, and for the best results 120 sperms are needed to surround each egg, in a quantity of water one-fiftieth of an inch in diameter, or about the one-thousandth part of an ordinary drop of water. So that every drop of water over an oyster bed should contain 120,000 sperms for the successful fertilization of the eggs spawned into that water.

Our microscopical researches this past season have tended to corroborate visually what was thus shown quantitatively by experiment.

While it may not be true in all cases, it is quite probable that, ordinarily, an oyster egg cannot be impregnated simply by coming into contact with a sperm. And it is certain that the sperms do not actively swim about and seek the egg. They simply lash their tails about, and if by accident they strike an egg, if the egg attracts them, their tails fasten on to the surface, and then they try to penetrate through the shell. Each egg may be covered with hundreds of such sperms, trying for a long time, in vain, to penetrate. There is but one place where the shell is open where the sperm can enter. When at last one does penetrate, it is due less to its own efforts than to the *fact that the egg draws it in. Then the other sperms cease to be* held, the shell becomes changed in some manner, and they drop off, dead.

These theoretical studies have plain, practical bearings upon the most prominent problems in oyster culture. We showed last year *that by mating certain oysters we got a greater percentage of develop-*

ment than when the "crossing" was with other individuals. This is in line with our general conclusion., viz, that the fry have varied degrees of viability. As yet, we are unable to tell why there is this difference; nor can we from present knowledge predict from an examination of the spawn, or from a knowledge of the history of the spawners, whether the offspring will be vigorous enough to live to adult age.

It becomes imperative, therefore, to give a minute study to the microscopical characters of oyster eggs; while this is a tedious work and will require a long series of investigations, it seems plain to the writer that there is no other way out. That is the principal reason why the present report is almost entirely confined to this aspect of the subject, though only in a general and introductory way, for more precise investigations will suggest themselves for future work. Such microscopical investigations can be supplemented by experiments of an apparently more direct and practical nature. Thus, the oysters from different regions, or the "natives" in the same region, may be variously crossed and the results noted. But the microscopical or theoretical researches are likely to be necessary and to prove the most "practical" in the end.

The problem of scientific oyster propagation from artificially-fertilized spawn, when fully solved, will doubtless offer important advantages to the oyster culturist, but it is so complex that it will not be readily nor immediately solved. A larger knowledge of the biological facts relating to the life of the oyster and its eggs is necessary before much practical headway can be made.

Sec. 3. Description of the Oyster Egg, Its Fertilization and Early Development.

Oyster eggs have an average diameter of one five-hundredths of an inch, and are therefore individually invisible to the naked eye, though when many of them are together (yet not so many but that the spaces between are at least equal to the diameter of an egg, and they form only one layer on the bottom of a small amount of water in a watch crystal) they appear as fine particles of dust if properly lighted from above and the background is dark.

When they are first taken from the oyster, and spread out on a glass slide, and viewed with a microscope, they are irregular in shape, but in general they are pear-shaped, being elongated, having a pointed and a large end. Figs. 1, 2.

If such eggs are left for a time in sea water, even when not fertilized, they slowly change their shapes, becoming at last spherical. Fig. 8. Northern native oyster eggs are more globular from the start than are the eggs of southern oysters. Inside of each egg at the center is a globular body or sac, which appears very clear, while the surrounding portion of the egg is more opaque, due to the presence of numerous small granules of yolk material. The clear body is called the nucleus, and within it, near one side, lies another and much smaller globe, as if the nucleus had itself a nucleus; this is the nucleolus. Besides the nucleolus there are several granules within the nucleus. They are composed of a substance called chromatin, and some of these granules are always present in a fixed number inside of all nuclei, not only of the eggs but also in the sperms and other cells of the oyster's tissues. They are called chromosomes. See Figs. 18, 26, 29, 36.

Chromatin is so called because it stains readily when a dye like carmine is applied to the egg. But there are several kinds of chromatin. Inside the nucleus are chromatin granules that are not chromosomes. Among these are at least two large grains that contain chromatin, which can be gradually transformed into a clear substance called hyaloplasm. In the nucleolus, also, there is a great deal of chromatin, which is also transformable into hyaloplasm. Fig. 29. Chromatin is manufactured there in considerable amount, and is pushed out into the cell. Some of the chromatin grains in the nucleus originated in the nucleolus. A good many of the chromatin bodies in the nucleus escape out of the nucleus into the protoplasm which is around the nucleus, and which is called cytoplasm. In the cytoplasm most of these chromatin grains become transformed into yolk granules, but they still retain the power of being stained. They are ultimately to be used as food for the protoplasm of the embryonic cells.

That word "protoplasm" is one designating the different substances of which cytoplasm and nucleus are composed, including both hyatoplasm and the various sorts of chromatin. But the material of which the yolk grains are made is called deuteroplasm.

Thus, the yolk material or deuteroplasm is made from a special sort of protoplasm known as chromatin, originating in the nucleus. The chromatin is itself made from the blood serum or lymph of the oyster, which soaks out of the blood system of the oyster, into the cells that are destined to become eggs.

Part of this blood serum or "food" of cells may possibly become transformed into protoplasm of one sort or another without first passing through the chromatin stage, but it is certain that most of the chromatin, aside from that in the chromosomes, becomes sooner or later transformed into different sorts of protoplasm, both inside of and outside of the nucleus. Yolk grains represent simply a storage of such chromatin for future use. The various bodies or grains of chromatin and hyaloplasm, etc., float in a sort of "sap" or juice, which consists of water holding salts and some proteids in solution. Doubtless this sap contains in solution, materials that have been made by the chromatin (and other protoplasmic action) inside the egg cells, as well as the materials in solution in the lymph absorbed from the oyster.

The egg is surrounded by a "shell." This is a very thin membrane, like that around a "yolk" of a hen's egg. It has an appreciable thickness, except at the small end of the oyster's egg. Here the shell is not only very thin, but frequently is drawn out like a funnel, and is either ruptured or has a natural opening (micropyle). See Fig. 26 *e. f.* The query arises, if the contents of the egg consist of a sap containing granules, why do they not flow out through the micropyle? This leads us to consider another constituent of the protoplasm. The most prominent part of the egg consists of a material to which the term protoplasm has been applied more especially. This material is nearly as clear as hyaloplasm, and exists in two forms, first as a compact, jelly-like substance, and second as a meshwork of fine strands, fibers, sheets and bubbles. The sap is held in the finest pores and spaces of the compact protoplasm, but in the interior of the bubbles and between the meshes and fibers it is held just as water is in a sponge. This protoplasm has remarkable powers of self-movement, and it can change its construction from the compact form to the fibrillar form or to the bubble form. It can make a wall around a space, and so it can hold contents just like a sac. The surface of the egg just beneath the shell consists of a thin sheet of compact protoplasm, so that were the shell stripped off the egg would still retain its shape. In fact, the protoplasm itself determines the shape of the egg.

The "network" of protoplasm exists in the interior of the egg, and is directly joined to the outer sheet (ectosarc) of protoplasm. This protoplasm also forms a wall about the nucleus, and inside the nucleus there is also a network of protoplasm of a special kind. The nucleolus itself has no wall, but consists of solid hyaloplasm, in which chromatin granules are distributed. The chromatin grains in

the nucleus, and the yolk grains of the cytoplasm, are held in the sap that fills the spaces of the protoplasm.

The nucleolus, and most of the chromatin grains in the nucleus, generally lie on the side of the nucleus which is next to the pointed end of the egg. Figs. 21, 24, 27. There is another body present in the egg, whose significance and origin are more obscure than is the case with the parts that have already been described. This body consists of a special sort of non-stainable protoplasm, which usually lies close against the outside of the nucleus at the larger end of the egg ; but it is very frequently present on the other side of the nucleus, and sometimes has other locations. It has the power to divide into two, and then the two parts lie at opposite poles of the nuclear globe. It undergoes very extraodinary changes in form in connection with the early history of the egg. See Figs. 15, 23, 24, 29, 30.

When the egg first leaves the oyster the protoplasm of the ectosarc forms a special receptive point at the small end of the egg ; into this the sperm fastens, and the protoplasm, rejecting other sperms, gradually draws it into the interior. Meanwhile the egg becomes globular and the shell thickens and closes up over the place where the sperm entered. See Figs. 29, 30, 35, 36.

The sperms in our experiments usually did not become attracted to the eggs as soon as they came into contact with them. For several minutes (averaging ten minutes) after sperms reach the vicinity of an egg they dance about, lashing their flagella or tails in all directions and paying no particular attention to the eggs. Occasionally one fastens to the egg-shell with its flagellum, and sits wagging its head out into the water, away from the shell. One or more may attach themselves to the pointed end of the egg. After ten minutes, suddenly, as if by preconcerted signal, there is increased activity among the sperms near the egg (within one-thousandth of an inch from its surface); in a few seconds the entire surface of the shell is covered witb struggling sperms, as if, like drowning people, they were trying to save their lives. And that is just what they are doing. Out of 250, more or fewer, that can touch the egg, only one enters the egg ; the others, after hanging onto the shell awhile, lose their power of movement ; they die and drop away. Only the sperm that reached the receptive spot has been chosen. The shell, perhaps, in addition to protecting the protoplasm from undesirable contacts, probably serves the purpose of preventing the entrance of more than one sperm. See Figs. 32, 33, 34.

What is the fate of the sperm that has entered ? No sooner has a

sperm been received than the nuclens seems to dissolve. Figs. 42, 43. The chromosomes at first stretch out into long, thin-beaded threads, that soon contract again into a compact form. Fig. 36. Meanwhile, the other chromatin becomes transformed into non-chromatic substances, the nucleolus disappears, the wall of the nucleus becomes irregular and faint, the clear bodies in the cytoplasm become peculiarly branched or star-like, with rays, the ectosarc shrinks away from the shell, and the shell is thrown into wrinkles, especially at the small end of the egg or its corresponding hemisphere. Figs. 37, 47. Meanwhile, the chromosomes have been transported to the large end of the egg and separated into two groups, just beneath the shell. Figs. 46 to 52. One group is then pushed out of and pinched away from the ectosarc, pushing the egg-shell up into a little mound, that grows higher and higher. This is called the first polar globule. Meanwhile, the chromosomes left in the egg are divided into two groups again, and one of the groups is pushed into the base of the first polar globule, where it becomes separated off from the ectosarc, as the second polar globule. Usually, only one projection is present, which contains the first group of chromosomes at its apex and the second at its base. But sometimes two separate projections are seen. *Fig. 59. The wrinkling of the egg is due to the active contraction* of the ectosarc as it pushes the globules out, and sometimes the contents of the egg burst out of the small end of the egg, where the shell is weak. Fig. 54.

The chromosomes left in the egg are now only one-fourth of the original number. They stretch into long, coiled, thin threads, that become enclosed by a nuclear sac. This new nucleus is called the female pronucleus; it lies near the polar globules. Figs. 58, 59. Meanwhile the head of the sperm that entered the egg has become transformed into a nucleus containing chromosomes, and is called the male pronucleus. Figs. 58, 60. While the polar globules are forming, this nucleus is dragged up towards the place where the female pronucleus will appear, and the female pronucleus is also drawn towards the male pronucleus; so they lie close together, usually near the large end of the egg. Figs. 61, 64, 68.

What is the mechanism which drags these nuclei, or their chromosomes, about? Evidently the one or two very active, clear bodies, that lie next to the nucleus in the cytoplasm. Possibly the one which lies nearest the micropylar pole receives the sperm. While the head of the sperm furnishes the chromosomes, the "neck" of the "lash," or propeller by which it swims, and by which it enters

the egg, furnishes a body called a "centrosome," which becomes the nucleus of the astrosphere. (The astrosphere is the clear body of active protoplasm, which become star-like, with rays streaming out in all directions.) Those rays that stretch out towards the nucleus, or its chromosomes, become attached to the latter, and so they are transported by the contractions of the various rays. Figs. 61, 62.

The clear body at the other pole of the egg nucleus (next to the large end of the egg, where the polar globules appear) has a centrosome of its own, and it becomes transformed into an astrosphere. At the same time it divides into two parts (Fig. 46), that remain connected by fine meridional strands of clear protoplasm, so that a figure is formed resembling a spindle, and so called. Figs. 48, 73. The chromosomes of the egg nucleus, after the nuclear wall has disappeared, become attached to the meridional threads, and they are dragged towards the surface of the egg. where they become pushed out. It is probable that one of the astrospheres enters the first polar globule, and so drags up towards itself half of the chromosomes. And it is presumed that the remaining astrosphere divides, so that one part can draw half of the remaining chromosomes into the second globule. Fig. 49.

At the close of the formation of these globules, the chromosomes that remain are transformed into à female nucleus, attached to a single centrosome or astrosphere, just as is the male pronucleus, and in fact the two are quite alike. Fig. 67. It is natural to call the one nearest the polar bodies the female, as it was derived from the same nucleus as the polar bodies. Otherwise it is impossible to tell "which is which." It is beyond our present purpose to discuss the general theories that biologists have advanced to explain these extraordinary performances.

We are concerned simply with a description of the stages, which we have pictured upon the plates accompanying this report. Suffice it to say that there are probably more complex relations (as yet not properly explained) in the egg than would appear from the preceding statements. We need hardly add that an egg (or for that matter any cell of a living being) is a marvelously complex piece of machinery. The various bodies inside the eggs are only small grains, even when viewed with the most powerful microscopes, and there are so many yolk grains in the way, that to disentangle chromosomes and centrosomes from other groups of granules in an oyster egg is a most difficult task, which cannot be more than partially successful.

The two pronuclei, each attached to an astrosphere, now become one nucleus, called a segmentation nucleus, and the rays of the two astrospheres *become united to form the first segmentation spindle* (Figs. 75, 76); but the chromosomes from each pronucleus keep, for a while, each by themselves, so that the nucleus is at first a double nucleus. Figs. 79, 82.

Each chromosome, after having been in a condition of a coiled, beaded thread, shortens up into a compact grain and then splits into two. At the same time the protoplasm contracts around the center of the spindle and causes the shell to wrinkle at the large end of the egg. Fig. 78. The two sets of chromosomes have, by splitting, become four, and then one set of male and one of female chromosomes is dragged up to each end of the spindle, towards the centrospheres, while the protoplasm becomes pinched into two cells, across the middle of the spindle. Figs. 79 to 85. Thus, each daughter cell has received a nucleus, which is just like the original segmentation nucleus of the egg, consisting of the same number of male and female chromosomes, joined to an atrosphere. At first the cells so formed are quite distinct (but their nuclei are indistinct in the living egg), while the protoplasm is active in division, but at last the chromosome become diffused and tbe protoplasm becomes passive, then the nucleus becomes distinct, in the so-called "resting stage." Figs. 84 to 91. The two cells thus formed are called either segments or blastomeres; and when there are large ones and small ones they are distinguished respectfully as macromeres and micromeres. The process of producing such cells by division of a single egg-cell is called either "cleavage" or "segmentation."

During the resting stage, the blastomeres are closely pressed together or compact. During the active stage they are sharply distinguished. It is a peculiar feature of the oyster egg that during the *first segmentation* there is separated more or less sharply by itself a sphere of yolk substance. Fig. 80. It seems that the yolk grams are crowded down into the micropylar hemisphere, and are shut out from participation in the division. This is true of all large eggs, and is remarkable in the oyster where the egg is so small. Usually, in small eggs, the entire egg divides into two. Owing to the small size of the yolk in the oyster egg, this yolk sphere appears like a blastomere itself, so that during ths first cleavage, the egg appears to consist of three blastomeres. Fig. 80. But the normal relations are restored during the resting stage, when one of the blastomeres

becomes reunited to the yolk, and so much larger than its mate. It is a macromere. Fig. 94.

After resting awhile, the nucleus in each blastomere becomes transformed for the second division, or cleavage. First, the astrosphere divides into two, and forms a spindle; next, the nucleus dissolves; at the same time, the chromosomes pass into the compact form and arrange themselves on the equator of the spindle, where each becomes split into two equal parts; then the two groups thus formed become separated, going to opposite ends of the spindle, where a new nucleus is made respectively to receive them. Then the cytoplasm becomes constricted across the middle of the spindle, and so we get four blastomeres, to one of which the yolk remains attached. Fig. 96 *e* This is the second cleavage. The third cleavage repeats the same story, and in its turn, results in the doubling of the cells, but this does not occur simultaneously in all the cells, because those with the most yolk divide more slowly. Figs. 98, 99. When the fourth cleavage is completed there are 16 nuclei, each representing a cell. As development proceeds the cells split into smaller and smaller cells until the little swimming fry is completed. Figs. 108 to 116. We shall not at this time carry the history any further. But we wish to speak of one point. "Male" and "female" chromosomes are both present in every nucleus. The nuclei divide, so that both sorts are always present. This does not mean that the chromatin in the male chromosomes is a different sort from that in the female chromosomes, but simply that the one set is derived from the sperm, while the other comes from the egg. Therefore, in each cell of the developing embryo is protoplasm from two parents. This protoplasm represents, not only the parent as regards sexual characters, but also all other characters that can be hereditarily transmitted, even those of *both sexes* of the family or breed to which the parent belongs. This is the first and great fundamental principle of the science of heredity and breeding. The sperm is called the "male" cell because it is derived from a "male" and it is *convenient* to use this term. The sperm is not sexed, though its parent is, and the embryo which it helps to create becomes either a male or a female during development. So, likewise, of the egg. The egg is a store-house of yolk-food for the use of the developing embryo; that is why it is larger than the sperm. It contains the chromosomes that represent the parent oyster, and which do not differ in appearance from the chromosomes brought by the sperm. The two sets of chromosomes play equal and similar parts in the division of every cell of the body. The object of having

two sets is not that either one alone is *impotent* to direct development, but that there is an *advantage* in uniting the qualities of two different individuals or races in one individual.

Sec. 4. *Journal of Operations, 1901, at Mott Oyster Experiment Station.*

June 21st, Friday. Temperature at 5:30 P. M., 79° Fah.

Oyster lot I., from creek at Oyster Station, consists of eight males (*A* to *H*) and five females (*a* to *e*).

Fertilized at 5:30 P. M., eggs of each female, by mixed sperms of all males; also used sperms of each male successively on mixed eggs of all females; and, finally, all males mixed, crossed with all females mixed. In all, fourteen experimental lots, all of which developed well.

Spawn lot 1. Union of all experiment lots (*A* to *H*) (*a* to *e*). Swimming embryos separated from sediment next morning, and distributed into separate tumblers and flat dishes, and left to themselves until June 26th, when it was found that the bottom and sides of several of the tumblers were covered with spat in the first shell stage. Most were dead, but many were still alive and free swimming. The tanks and claires for planting these were not ready, and none remained alive after the seventh day.

June 27th, Thursday. Temperature, 80° Fah.

Oyster lot II., 4:45 P. M. Two males (*A*, *B*) and four females (*a* to *d*). Eggs were irregular in size, mostly rounded and coarsely granular, with *debris*. Female (*c*) had very few, as if spawned out. One oyster, opened at noon, had its gonad full of gregarines.

Fertilized at 4:50 P. M., eggs of *a to d* separately, by mixed *A*, *B*, and made a gross lot from all eggs of all females; five experimental lots in all.

Spawn lot 2. Union of first four experiment lots of oyster lot II. Used for study. Polar globules formed at 5:30. Cleavage at 5:48, preceded by wrinkling of large or polar globule end of egg. At 6:22 many eggs had reached four and eight-cell stages. Next morning had a fair lot of swimming embryos or "fry." Of these most all were dead by July 2d, five days.

Experiment lot No. 5 was so slimy it could not be cleaned; few eggs segmented and none reached the "fry" stage.

June 28th, Friday. Air 85° Fah., and water 82° Fah., at 9 A. M.

Oyster lot III. Three males, *A* to *C*; eleven females, *a* to *k*. Eggs

of *d*, *e*, *f* became slimy in water; parasitic amœbas in *g* and *h*; bacteria in *i* and *j*; eggs very crinkly in *k*.

Fertilized at 9 A. M., eggs of females separately, by mixed sperms of *A* to *C*. Few eggs developed, except in *b*. Second polar globule appeared at 9:37; first cleavage preceded by wrinkling of surface of large end of egg at 9:53; second cleavage at 10:05.

Spawn lot 3. Union of best results of experiments with oyster lot III. Few survived five days, having reached shell stage.

Spawn lot 4. Fertilized at 3 P. M., eggs of *b*, oyster lot III., studied on slide. Sperm seems to enter at small end of egg; kinetic figures in nucleus at 3:10, but at 3:47 no further development, due to lack of oxygen under the cover slip.

July 2d, Tuesday. Air 96° Fah., water 90°.

Oyster lot IV. Nine poor females (*a* to *i*), "Hog Island plants," from creek, and three (*j* to *l*) "naturals" from pond. No eggs in *c*, *g* and *i*; best is *l*. The oysters seemed to have spawned out in part, and the eggs were decomposing and granular. Fig. 3.

Spawn lot 5. At 8:15 A. M., fertilized separately, *a* to *l* of lot IV., and stages of segmentation shown at 9 A. M., and swimming "fry" at 11 A. M.

Spawn lot 6. At 9:30 A. M., fertilized a large quantity of roe from *l*, lot IV. Weather so hot had to stop work. These lots were treated by killing fluids July 4th, which date see.

In afternoon experimented with killing and staining fluids. Sperms were diluted in oyster serum and dried on cover slips, then treated respectively with picric acid (saturated), corrosive sublimate (saturated), nitric acid (20 per cent.), formalin (10 per cent.), acetic acid (15 per cent.), alcohol (95 per cent.) After washing, the preparations were stained with picro-carmine (Ranvier's), borax carmine, hematoxylin (Bohmer's) and hemalum.

Also tried same reagents on the moist eggs in watch glasses, but did not obtain so good results as with eggs as sperms.

July 3d, Wednesday. Water 80° Fah., air 85° Fah., at 8 A. M.; 94° at noon.

Oyster lot V. Oysters of yesterday, kept in basket submerged in creek, originally brought from pond. Opened *A* to *C*, Hog Island males, and *D* "pond native." Sperms in *B* are active. Also opened one native with gonad filled with gregarines. Opened three "pond native" females (*a* to *c*) and one Hog Island female (*d*).

Spawn lot 7. At 8:30 A. M., fertilized *a* to *d* separately. Best development in *c* and *d*.

Spawn lot 8. At 9 A. M., fertilized *a* to *d*, mixed.

Oyster lot VI. Brought by Watson T. Sooy, member of the State Oyster and Shell Commission, consisting of "naturals" from Mullica river and James River "plants." Mr. Sooy experimented, crossing Mullica native females with James River males. The Biologist spent rest of day studying the eggs of *c*, *d* (lot V.) in serum. The nuclear chromatin, at noon, is undergoing rapid and constant changes, as is also the astrosphere. Fig. 13.

At 3 P. M. there seem to be two clear bodies outside of, and in contact with, the nucleus.

On adding water, there are visible two groups of refringent (chromatin?) granules inside of the nucleus, each accompanied by a nucleolus. After two hours some of the eggs assume the spherical form. Fig. 9.

July 4th, Thursday. Lowest temperature, 80° Fah., highest 90°.

Lots V. and VI. show (as is usual) eggs in all and in unfertile stages of arrested development. They were treated with picric acid, corrosive sublimate, nitric acid, formalin, acetic acid, and alcohol, respectively.

Oyster lot VII. Opened pond oysters. One contained gregarines. Females mostly in poor condition, with decomposing eggs: Three females, *a*, *b*, *c*; only *b* was good. Two native (*A*, *B*) and three Hog Island (*C*, *D*, *E*) males, of which *D* showed active sperms.

Spawn lot 9. At 12:30 P. M., fertilized mixed lot eggs by mixed sperms, *D*, *C* predominating.

Studied effect of reagents on eggs of *b*, lot VII. Nitric acid causes nucleus to undergo amœboid contortions and even to burst, while the chromatin is extruded at the micropylar end of egg. Or there may be simply extrusion of cytoplasm at this pole, the nucleus remaining intact. Fig. 54.

Formalin also causes nuclear distortion, but less bursting.

Eggs unfertilized of *b*, left three to five hours in sea water, lose their nuclei, become spherical, and on treatment with contracting reagents like alcohol, &c., extrude a globule at one or at both poles. Stained with picro-carmine, the nucleus is found to contain delicate, scattered chromosomes and dissolved nucleoli in quite a number of cases.

July 5th, Friday. Temperature is 84° Fah. at 8 A. M. and 92° at noon.

Oyster lot VIII. Eighteen Hog Island and two native oysters from the pond, equally divided between the sexes, thus, *A* to *I*, *J*, and *a* to *i*, *j*. July 9th, all had died.

Spawn lot 10. At 10:15 A. M., fertilized, *a* to *j* mixed, by *A* to *J* mixed. All dead by July 9th.

Continued study of effects of reagents : Acetic acid acts much like nitric, in causing extrusions at one or both poles of eggs, and deformations of the nucleus. Fig 22.

Corrosive sublimate causes shrinkage of the cytoplasm and wrinkling of the egg membrane, but the nucleus remains normal.

Picric acid causes least deformity.

July 9th, Tuesday. Temperature, 80° Fah.

Fertilized at 5:25 P. M., clam eggs, and secured an abnormal development; the spawn looks as if not yet ripe. Next day had swimming some clam "fry," which were prepared for mounting by killing with corrosive sublimate and staining with picro-carmine.

July 10th, Wednesday. Temperature at 7 A. M., 71°; at noon, 80° Fah.

Oyter lot IX. Fine lot of pond oysters filled with spawn, viz., two Hog Islands, *A* and *a*, and thirteen natives, *B*, *C*, and *b* to *k*. Sperms motile in *A* and *C*, and eggs very fine except in *b*, *e*, *i*.

Spawn lot 11. At 12:30 P. M., fertilized mixed *a* to *k*, lot IX., by *A*, *C*. Got a good development of the heavy eggs, but a great many are light and decompose. The fry are not very active, and many decompose during next day (during which some were planted in tank), and by July 12th no live ones remain. Having ascertained that picro-carmine gives best stain, we try its power, following various reagents, upon serum eggs: After alcohol, good ; after iodine, very good ; after sublimate, very good ; after formalin, good ; after picric acid, quite good ; after osmic acid, poor. The other killing reagents give poor preparations.

July 11th, Thursday. Temperature, 86° Fah. at noon.

Oyster lot X. Fresh supply of oysters from same source as lot IX., but had lain in garvey load over night.

Spawn lot 12. At 11:15 A. M., put eggs unfertilized into sea water ; but a few sperms got in accidentally. Used this and eggs of lot X. for further studies in technique. Prepared series of slides, showing effect of delayed fertilization upon eggs left in opened oyster, and second, left in water until 4:15 P. M., supplementary to the studies made July 3d and 4th.

July 12th, Friday. Temperature, 80° Fah. at 7 A. M., 78° Fah. at 5 P. M. A northeastern storm broke at noon.

Oyster lot XI. Same source as lot X.

Spawn lot 13. At 9:10 A. M., fertilized *a*, *b*, *c*, by *A*, *B*, *C*, lot XI. Good development results ; swimming fry present at 2:30 P. M.

Oyster lot XII. Oysters freshly removed from creek. (?)

Oysters had poor and granular eggs.

Spawn lot 14. At 11:55 A. M., fertilized samples of XII. Poor development.

Continued studies in staining and mounting eggs of XI. and XII.; former termed "garvey eggs."

Techinque nearly perfected; most difficulty is to properly dehydrate eggs before mounting, owing to moist atmosphere. Result secured by treating eggs under cover slip, entangled in a film of cotton fibers, and using filter paper to draw fluids through.

At 6 P. M., stained embryos, lot XIII.

July 13th, Saturday. Temperature at 7 A. M., 73° Fah. Northeaster raging.

So much moisture in air, it was impossible to mount the preparations, so treated *debris* from lot XIV. with formalin and iodine, stained with picro-carmine, cleared with acid alcohol and conserved the material in vial No. 10.

Seems as if the developmental stages do not stain so readily as the unfertilized eggs.

July 16th, Tuesday. Temperature, 80° Fah. at 9 A. M., 88° Fah. in afternoon. Cloudy and muggy.

Oyster lot XIII. Five ripe males, *A* to *E*, and four females, *a* to *d*, not very promising.

Spawn lot 15. At 9:30 A. M., fertilized sample, and by 10:30 found eggs were good because the polar globules were then forming. At 10:55 segmentation stages numerous. Planted in tank at evening of July 17th.

Spawn lot 16. At 10:40 A. M., fertilized *a* to *d* (XIII.), separately, by mixed *A* to *E.* Good development at 12:30 in *b*, *c*, *d*.

Spawn lot 17. At 10:55 A. M., fertilized *a* to *d* (XIII.) mixed, also placed some of these in life-box, but they fail to develop. Those not in life-box are also backward.

Spawn lot 18. At 1:35 P. M., fertilized eggs of *b*, *c*, *d* (XIII.), and made preparations of portions of the lot at each successive minute for twenty-five minutes, conserving them in vials Nos. 11 to 36 inclusive, as see table at close of this section. The reagents used were iodine, sublimate and formalin, in rotation; and the stain was picro-carmine; the "wash" was 70 per cent. alcohol, containing 3 per cent. muriatic acid. All the operations were conducted in half-drachm, corked vials. Preparations 11 to 16 were also mounted in balsam, on slides, for microscopic examination, though the humidity of the air made this

operation a delicate one. The sublimate specimens proving darkest, and not easily cleared, this reagent was ruled out in subsequent work.

July 17th, Wednesday. Temperature, 80° Fah. at 7 A. M., 88° Fah. at noon.

The air was less humid in the forenoon than in the afternoon, permitting of mounting preparations, 17 to 36, at an average speed of 10 minutes apiece.

Oyster lot XIV. Four good males, *A* to *D*, nine poor females, *a* to *i*.

Spawn lot 19. At 3 P. M., fertilized *a* to *e* (XIV.), separately.

At 3:55 P. M., all show good development.

Spawn lot 20. At 3:55 P. M., fertilized *a* to *e* (XIV.), separately, and *f* to *i*, mixed.

Spawn lot 21. A union of lots, 19 and 20.

From this lot preparations were made in the vials Nos. 37 to 114, all the odd Nos. being treated with iodine and the even Nos. with formalin. Nos. 40 to 99 are taken one minute apart, the others 5 to 20 minutes, as see table at close of section.

The series was stained with picro-carmine next day, July 18th.

This set of vials, from 11 to 114, thus gives a complete series from fertilization to the time the swimming "fry" is developed.

This series was mounted at the laboratory at New Brunswick, and further study showed that iodine was superior to formalin as a killing fluid. See section on technique.

July 18th, Thursday. Temperature, 76° at 7 A. M., 83° at noon, 88° at 4:40 P. M. Forenoon stormy.

Oyster lot XV. Three ripe males, *A* to *C*, and four poor females, *a* to *e*.

Spawn lot 22. At 4:35, fertilized *a* to *e*, mixed, by *A* to *C*. Planted July 19th, in tank and garvey.

Experimented fertilizing eggs under cover slip and observing the impregnation. Sperms added by irrigation soon become quiet from lack of oxygen, but on adding sea water, or lifting the cover, they "dance" again. Some eggs attract them more than others. The attraction does not occur right away.

Fertilized at 4:40 P. M., egg begins wrinkling, and no nucleus visible at 4:50 P. M., and first polar globule spindle seen at 4:55 P. M.; polar globule seems to have been started at 5 P. M. No further development, due to lack of oxygen.

Unfertilized eggs round up and nucleus becomes faint in outline and irregular after lying a half hour in water. Sperms added at 5:30 P. M. to such eggs, do not appear attracted.

July 19th, Friday. Temperature, 78° at 7:45 A. M.; 86° at 10 A. M.

Oyster lot XVI. One ripe male, six poor females, selected "best." Many amœbas present.

Continued fertilization observations under the microscope. Found that sperms first attach themselves to eggs by their flagella and then try to bore through egg-shell with the "neck-piece." Gradually they draw the head closer to the egg, and at last become flattened against its surface.

Fertilized at 9:55 (?) A. M. Nucleus becomes faint at 10:07 A. M. to 10:20 P. M., with wrinkling and formation of polar globules.

Fertilized at 11 A. M. The nucleus has disappeared by 11:35 P. M. and wrinkling begun at 11:55 P. M.

Fertilized at 12:25 P. M. The sperms won't swim to an egg, but must be carried against it. At 12:30 P. M. the sperms reach the egg. At 12:43 P. M. they begin attaching to the eggs until some of the eggs are covered, as with a swarm of bees, thus impregnation probably did not begin until 13 minutes after fertilization. The great swarm prevents seeing which sperm enters the egg. The small end of egg seems to attract most and earliest, but entire surface becomes covered. The sperms attach first by their tails.

At 1 P. M. the sperms are more quiet, and many drop away from the egg's surface. The eggs more round and opaque. They now begin wrinkling, and by 1:07 P. M. the first polar globule becomes extruded; completed at 1:13 P. M. The second globule is extruded at 1:18 P. M. The first cleavage spindle, with formation of a constriction between the yolk hemisphere and the germinal hemisphere, and wrinkling of the shell of the latter is formed at 1:25 P. M. The second cleavage occurs at 1:46 P. M., but many eggs are slower, and pass into a quiescent state at 1:54 and 2:07 P. M., with both blastomeres closely united with the yolk, one, in fact, indistinguishable from it, and at all stages more closely united to yolk than the other.

Oyster lot XVII. One female from Elder Creek.

Fertilized at 2:30 P. M., eggs of XVII. Nucleus disappeared at 2.40 P. M.; the micropyle end begins wrinkling at 2:50 P. M.; first polar spindle (?) at 3 P. M. Polar globules formed before 3:25 P. M.

August 28th, Tuesday. Temperature, 74° at 11 A. M.

Oyster lot XVIII. From creek at station. Two ripe males (*A, B.*); two "spawny" females (*a, b*) and six poor females (*c* to *h*) with rounded eggs.

Spawn lot 23. At 10:50 A. M., fertilized *c* to *h* (XVIII.) by *A*, *B*. Only half a per cent. of development.

Spawn lot 24. At 11 A. M., fertilized *a*, *b* (XVIII.) mixed, by *A*, *B*. mixed. About 75 per cent. undergo development. Wrinkling of small end begins at 11:35 A. M., first polar globule appears at 11:40 A. M., second globule completed at 11:52 A. M.; first cleavage, sharpest at 12:10. Egg compact and nuclei visible at 12:17 P. M.

Fertilized at 1:35 P. M., eggs of *a*, XVIII., in life-box. Nucleus disappears at 1:52; polar globule formed at 2:07 P. M.; second globule at 2:29 P. M.

Fertilized at 3:57 P. M., eggs of *a*, XVIII. At 4:07 P. M. the sperms begin to be numerously attracted; sperms still attached, but nucleus gone at 4:20 P. M. Eggs take on bizarre forms; due to evaporation, at 4:45 P. M.; put in vial 200. Show two globules at each pole. Eggs left in dying tissues of oyster do not round up as when put in sea water.

August 29th, Wednesday. Temperature, 75° at 10 A. M. and 6 P. M.; 80° at noon.

Oyster lot XIX. Kept in basket in creek. Six ripe males (*A* to *F*), four passable females (*a* to *d*), and two apparently better females (*e*, *f*).

Spawn lot 25. At 9 A. M., fertilized *a* to *d* and *e*, *f*, in two separate tumblers.

At 11 A. M., a few eggs developing in *a* to *d* and still fewer in *e*, *f*.

Fertilized at 9:45 P. M., eggs of *e* on slide; eggs wrinkling at 9:52, the nucleus being amœboid and obscure; sperms gather about choice eggs.

Fertilized at 10:20 A. M. At 10:40 A. M., sperms gathered about special eggs. Also fertilized at 11:20 A. M., sample of XX.

Oyster lot XX. Fresh from pond; very "spawny." Five good females (*a* to *e*) and seven good males (*A* to *G*).

Spawn lot 26. At 12:25 P. M., fertilized *a* to *e*, XX., separately, by mixed *A* to *G*. Did not care for them properly, being engaged in observations on mixed eggs of *a* to *e*, fertilized on slide. Spawn lot 26 failed to develop, but experiments on slide gave good development.

Fertilized at 12:50 P. M., eggs of XX., *a* to *e*. Sperms at once fasten to all eggs abundantly; wrinkling at 1:02 P. M.

Fertilized at 1:20 P. M., eggs of XX. Polar globule at 1:50 P. M.; second at 1:55 P. M.; first cleavage spindle at 2 P. M.; most sharp at 2:06 to 2:14 P. M.; compact again at 2:11 to 2:25 P. M.; second

cleavage at 2:29 P. M.; compact at 2:34 P. M.; third cleavage at 2:53 P. M.

The eggs near the center of the life-box are far behind those at the periphery, owing to lack of oxygen. In fact, only a small proportion develop at all in the center, while nearly all develop at the periphery of the drop.

Experimented fertilizing eggs of clams at 3:45 P. M., but the sperms were not active, though the eggs seemed ripe. Put sperm in vial 201 and *eggs in 202. Eggs show well marked micropyle.*

Fertilized at 5:40 P. M., sample of XX., opened at noon. At 6 P. M. nucleus disappears and wrinkling begins; at 6:15 P. M., first polar globule made; at 6:30 P. M. the second completed. At 6:45 P. M. put eggs into vial 203.

From the data presented in the foregoing journal, relative to the rate of development of the different oyster spawn lots, we have collated the figures in the following table:

Table Showing Number of Minutes After Fertilization that Various Developmental Changes Occur in Oyster Eggs at Different Air-Temperatures.

DATE.	Temperature.	Impregnation.	Nucleus fades.	Shell wrinkles.	*First polar* globule.	Second polar globule.	*First cleavage* spindle.	Segments, sharp.	Segments, compact.	Second cleavage, sharp.	Second cleavage, compact.	Third cleavage.	Embryo swims.
August 28	74	......	......	85	40	52	......	70	77	......	......	......	......
" 28	74	......	17	......	82	54	......	......	......	......	......	......	......
" 28	74	*10*	*23*	......	......	......	......	......	......	......	......	......	......
" 29	75	......	20	......	85	60	......	......	......	......	......	......	......
" 29	80	1	......	12	......	......	......	......	......	......	......	......	......
" 29	80	......	......	......	80	35	40	46	51	69	74	98	......
" 29	80	......	......	......	......	......	......	54	65	......	......	......	......
June 27	80	......	......	......	......	40	......	58	......	......	......	92	......
July 12	80	......	......	......	......	......	......	......	......	......	......	......	820
" 16	80	......	......	......	......	60	......	......	85	......	......	......	......
June 28	85	......	......	......	......	87	......	58	......	65	......	......	......
July 19	86	......	35	55	......	......	......	......	......	......	......	......	......
" 19	86	......	12	......	25	......	......	......	......	......	......	......	......
" 19	86	13	......	30	37	48	......	55	64	76	97	......	......
" 19	86	......	10	20	30	50	......	......	......	......	......	......	......
" 17	88	8	15	......	24	28	33	44	58	64	72	90	800
" 18	88	......	10	15	20	......	......	......	......	......	......	......	......
" 2	96	......	......	......	......	......	......	......	45	......	......	......	165

Remarks on the Foregoing Table.

The data have been presented in the order of the height of the temperature, and if the numbers be read in the different columns, from below upwards, it will be seen that they successively become greater, thus illustrating the well-known law that a higher temperature accelerates development. This law was also illustrated by a table in our report for 1890.

There are, however, some irregularities in the present table that need to be explained :

Thus, the cases of July 16th, 19th, are slow at a high temperature, while those of August 29th show a remarkable rate of development for so low a temperature. These results are to be explained by supposing that the particular oysters used in the latter instance were extraordinarily vigorous. We know from this and from previous reports that the eggs of any one oyster do not all develop at the same rate, and that the vigor of all the eggs in an oyster rapidly declines after the oyster is removed from its native element. We also have abundant evidence that oysters differ greatly in the character and fertility of their eggs, even when first taken from the water.

Again, we have, in this and previous reports, shown that the rate of development is dependent upon the supply of oxygen and the extent to which the eggs are stirred and crowded.

Again, the various events are not sharp ones, but each occupies some time, beginning and ending with imperceptible changes and progressing to a climax gradually. It is difficult to observe the changes of similar phases in different lots of eggs.

Finally, the temperature of the water is not equally a fixed number of degrees below that of the air. Also, the temperatures given are those obtaining at the beginning of each experiment, and therefore not accurately the average temperature in each experiment.

These facts must all be considered in a set of experiments, in which conclusions are made, based on the variations in the rate of development. But, undoubtedly, the rate of development is an important index to the vigor and character of the spawn, and may, perhaps, come to figure prominently in a practical system of oyster propagation. Therefore, studies along this line cannot be ignored during this, the experimental period of scientific oyster propagation. It is plain that next season a more detailed and accurate set of experiments should be carried out to determine the formula representing

the normal rate of development, under different conditions, in order that significant departures from this rate may be noted and their bearing on the outcome be seen.

Table Showing Mode of Preparation and Age (in Minutes) of Fertilized Oyster Eggs in the Vials Prepared July 16th and 17th.

No. vial.	Reagent.	Age.	No. vial.	Reagent.	Age.	No. vial.	Reagent.	Age.
11	Iod.	0	46	Form.	27, 82	81	Iod.	62, 117
12	Sub.	½	47	Iod.	28, 83	82	Form.	63, 118
13	Form.	1½	48	Form.	29, 84	83	Iod.	64, 119
14	Iod.	2½	49	Iod.	30, 85	84	Form.	65, 120
15	Sub.	3½	50	Form.	31, 86	85	Iod.	66, 121
16	Form.	4½	51	Iod.	32, 87	86	Form.	67, 122
17	Iod.	5½	52	Form.	33, 88	87	Iod.	68, 123
18	Sub.	6½	53	Iod.	34, 89	88	Form.	69, 124
19	Form.	7½	54	Form.	35, 90	89	Iod.	70, 125
20	Iod.	8½	55	Iod.	36, 91	90	Form.	71, 126
21	Iod.	9½	56	Form.	37, 92	91	Iod.	72, 127
22	Sub.	10½	57	Iod.	38, 93	92	Form.	73, 128
23	Form.	11	58	Form	39, 94	93	Iod.	74, 129
24	Iod.	12	59	Iod.	40, 95	94	Form.	75, 130
25	Sub.	13	60	Form.	41, 96	95	Iod.	76, 131
26	Form.	14	61	Iod.	42, 97	96	Form.	77 132
27	Iod.	15	62	Form.	43, 98	97	Iod.	78, 133
28	Sub.	16	63	Iod.	44, 99	98	Form.	79, 134
29	Form.	17	64	Form.	45, 100	99	Iod.	80, 135
30	Iod.	18	65	Iod.	46, 101	100	Form.	85, 140
31	Iod.	19	66	Form.	47, 102	101	Iod.	95, 150
32	Sub.	20	67	Iod.	48, 103	102	Form.	105, 160
33	Form.	21	68	Form.	49, 104	103	Iod.	115, 170
34	Iod.	22	69	Iod.	50, 105	104	Form.	125, 180
35	Sub.	23	70	Form.	51, 106	105	Iod.	135, 190
36	Form.	24	71	Iod.	52, 107	106	Form.	145, 200
37	Iod.	10, 25, 65	72	Form.	53, 108	107	Iod.	155, 210
38	Sub.	15, 70	73	Iod.	54, 109	108	Form.	165, 220
39	Form.	20, 75	74	Form.	55, 110	109	Iod.	175, 230
40	Iod.	21, 76	75	Iod.	56, 111	110	Form.	185, 240
41	Iod.	22, 77	76	Form.	57, 112	111	Iod.	205, 260
42	Form.	23, 78	77	Iod.	58, 113	112	Form.	225, 280
43	Iod.	24, 79	78	Form.	59, 114	113	Iod.	245, 300
44	Form.	25, 80	79	Iod.	60, 115	114	F. I. S.	all stages.
45	Iod.	26, 81	80	Form.	61, 116			

Sec. 5. Remarks on Technique.

Considerable time was spent in trying about a dozen killing reagents and several staining fluids, and it was ascertained that the most satisfactory killing fluid is a dilute solution of ordinary iodine in potassium iodide, as used to detect starch in micro-botanical technique. Of all the stains tried, Ranvier's picro-carmine gave the best results.

Two distinct ways of applying these fluids were used. If one simply wishes to preserve a considerable quantity of the eggs, the best way is to use small vials with corks. The eggs are first washed, and then, together with sea water, are transferred by dropper into the bottles, where they are allowed to stand five minutes, to settle. Most of the water is then drawn off, and three to five drops of the killing fluid are added. We used the various reagents stronger than is customary, because of the large dilution due to the water in the vials.

After five or ten minutes (longer will not injure) the bottles are filled with soft water, and, after settling, the water is drawn off as much as possible and 60 per cent. alcohol is added, until the bottle is half full. This is allowed to act at least ten minutes, and is then drawn off and three or four drops of the stain added to the sediment. After ten minutes the bottles are filled with soft water, and as soon as settled this is drawn off.

Then five or ten drops of 60 per cent. alcohol, acidulated to the 3 per cent. limit with hydrochloric acid, are added and allowed to act about five minutes. Then the bottle is filled with water or weak alcohol, and as soon as possible is decanted as before. Again the bottles are half filled with 60 to 70 per cent. alcohol, and this is taken off and 80 to 90 per cent. added in small quantity.

The eggs may remain in this indefinitely. As soon as they are to be mounted the bottles are half filled with 95 per cent. alcohol, which, after five minutes, is taken off rapidly and as nearly completely as possible, and its place given to absolute alcohol; the vials are corked quickly. After five or ten minutes the alcohol can either be removed, or diluted with xylene and removed, and pure xylene added. Do not expose absolute alcohol, or xylene and alcohol mixed, to moist air. Immediately the eggs, if properly dehydrated, become clear. The xylene is removed as far as convenient, and balsam, diluted with xylene sufficiently to render it readily lifted by the dropper, is added to a depth of a tenth of an inch or so.

The eggs are now ready to mount, but may remain as they are until convenient to use. In mounting, a drop of the contents of the

bottle is lifted and placed carefully on the clean slide. It will spread, run off and soon become dry, leaving the eggs. Before it is dry, take a few fibers of absorbent cotton and lay them on the moist place, or the cotton may be placed dry on the slides, and the drop containing the eggs, be poured over it. Do not have very many fibers ; ten or fifteen are sufficient. Now place a drop of ordinary fluid balsam on the eggs, and stir gently with the point of a needle until the eggs are properly mixed with the mounting medium. Then cover with a clean cover. No. 1. Do not get more balsam on than necessary, as the film may be too thick for high powers to reach the eggs. Neither should the cotton fibers be bunched, but be evenly distributed.

The slide may now be studied with water immersion lenses. Do not try oil immersion until the cover has properly dried fast. The eggs are easily crushed by pressure and motion of cover.

In case a few special eggs are to be mounted, the preparation should be treated on a slide from start to finish. Such a set of eggs should be in sea water, under a cover, held up by a few cotton fibers, or the eggs may, if numerous enough, be treated in a watch-crystal, at least for several of the early stages, as described for the vials, and then transferred to the slide and covered, as described, and the manipulations completed there.

Small strips of filter paper are used to draw the various fluids successively through, beneath the cover. The reagents are applied drop by drop at the opposite edge of the cover. The succession of the fluids will, in general, be like that used for the bottles. The process may be watched with the microscope, but the naked eye soon learns to detect, by delicate "schlieren," when the new fluid has replaced the old, in each case, and so the process is a litte more expeditious, except when many preparations are made at once. Only two to four preparations can be run at once by this method.

Care must be used that, when dehydrating with absolute alcohol, a drop of tbis does not stand outside the cover without being soaked up, because, in a humid atmosphere, as is usual at the shore, it will almost at once become watery and produce trouble, if not with the xylol, then with the balsam following. This balsam should be diluted "xylol balsam."

The figures on the following plates have, in general, been originally drawn in pencil, from nature, upon white paper, with a camera lucida. Most of the figures were projected at 1,000 diameters, and viewed with from 500 to 1,000 diameters, when drawn free hand.

This applies more especially to the mounted eggs. The living eggs studied in the field were more often drawn free hand and magnified from 200 to 500 diameters.

The figures thus produced have not been copied, but traced in india ink and mounted for photo-electrotype reproduction, being thus reduced one-half, so that most of the figures (all the large ones) are shown on the plates of this report, magnified 500 diameters, and the others proportionally.

It has not been thought necessary, when dealing with so many views of the same object, to state the magnification in each case, the foregoing explanation being thought sufficient.

While the oyster egg is very minute, there is still enough yolk granules in it to render the delicate nuclear figures within the egg very obscure. Many thousands of eggs have been studied, and thousands of drawings made, from which those reproduced have been chosen. In this way it was possible to see what features were common, and what accidental, to the eggs. But it is probable that some things have been represented which were only accidental grouping of yolk grains, or at least, non-chromatinic aggregations of protoplasm, shadows of *debris* on the egg-shell, etc. But it is thought that these erroneous results have been well nigh eliminated.

On the other hand, undoubtedly, there are structures present that were not seen, and so are not put into the drawings ; and thus they are not complete. Still, the general results tally fairly well with the knowledge we have of maturation of eggs in general. Nevertheless, there are some peculiarities that require to be carefully looked into, and some important points, where there is either doubt of the true interpretation or the links have been guessed ; and it is evident that some of those guesses may be erroneous.

Most of the eggs are in outline diagram and not artistically finished. We have shown only the significant structures and left out the yolk grains.

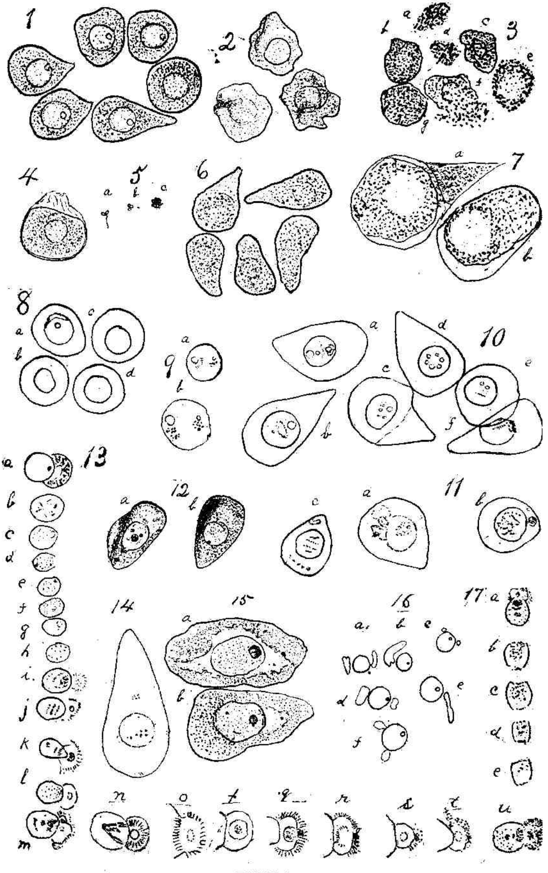


PLATE I.

EXPLANATION OF PLATE I.

CONSTITUENTS OF OYSTER EGG.

Fig. 1. Group of eggs in good condition, as seen under the microscope.

Fig. 2. Eggs from a "native" oyster. They are irregular in shape, owing to the fact that they have been crowded together in the ovary. After lying a short time in water they attain a more regular shape.

Fig. 3. Group of "poor" eggs, showing the coarse grains of yolk, etc., which they contain, and also showing how the shell breaks easily and sets free these grains.

Fig. 4. An egg with the shell membrane pulled out from the yolk and torn open at the apex.

Fig 5. Sperms from an unripe male, showing how they are still attached to one another in groups of two or more.

Fig. 6. A group of eggs from a southern oyster, which has been for several hours opened. Shows that the shape of the eggs is retained, but that the nucleus is becoming obscure.

Fig. 7. Two eggs like those of Fig. 3, but more highly magnified, to show that the outlines or wall of the nucleus have faded and that the yolk has shrunken away from the shell in certain parts.

Fig. 8. Group of eggs like those at 1, 2 or 6, but drawn without the yolk grains, after lying in sea water awhile. If they are like those of Fig. 6 it takes five or six hours to reach this result. If they are fresh and are fertilized, it takes only a few minutes. If fresh and unfertilized, it takes a varying length of time between the extremes indicated, for the eggs to reach the globular form.

Fig. 9. Two nuclei from eggs like those of Fig. 10. It will be seen that the nucleus contains a primary and a secondary nucleolus, each accompanied by a group of chromatin bodies, possibly chromosomes. There seem to be nine of these with the smaller nucleolus, and two groups, of seven each, with the large nucleolus. In 9 *a* the units of the latter group are radially arranged on one side of the nucleolus.

Fig. 10. A group of eggs from an oyster which has been opened for some hours, on a very hot day, showing the diverse figures the bodies within the nucleus assume. In 10 *b*, for example, all the chromosomes (?) have arranged themselves in an equatorial ring between the two nucleoli.

Fig. 11. Eggs from the same lot as Fig. 10, showing that at the large end of egg *a*, and smal end of *b* there is a complex figure, probably representing the astrosphere.

Fig. 12. Similar eggs to those of 10 and 11, showing the activities of the astrospheres at the opposite poles of the nucleus. In 12 *a* the astrosphere at the large end of the egg is active, and in *c* it has broken into a row of bodies. Within the nucleus the chromosomes have arranged themselves as for a division.

Fig 13, *a* to *u*. Drawings of the same nucleus with the principal astrosphere, for 30 consecutive minutes. The nucleus without the astrosphere is shown in *b* to *h*, and the astrosphere alone in *o* to *t*. The astrosphere itself has a nucleus, called the centrosome. In addition to that, *there are other centers active in the periphery of the astrosphere, as see m. q, s, t. etc.* The chromatin inside the egg nucleus goes through various evolutions, resembling those of cell divisions, hnt they never accomplish any division of nucleus, etc.

Fig. 14. An egg like those of Figs. 10, 11, 12 and 13, treated with corrosive sublimate, stained with borax-carmine and examined, mounted in balsam, showing seven chromosomes in the nucleus, a group of granules on the small-end side of the nucleus, probably belonging to the corresponding astrosphere, and two groups belonging to the astrosphere of the large pole of the egg.

Fig. 15. Shows similar eggs treated with iodine, stained and monnted. In *a* the clear protoplasm of the astrospheres lies at both poles of the nucleus, and each contains, apparently, a centrosome. In *b* only one astrosphere is visible.

Fig 16. A group of nuclei, with accompanying astrospheric (clear) bodies, from the same lot of eggs as Figs. 10 to 15, at a later hour, and viewed in the fresh condition in their own serum, *b* and *e*, shows only one clear body, hut probably ready to divide.

Fig. 17. A single nucleus, seen for 20 consecutive minutes; same lot as Fig. 13. Only in *a* is the astrosphere shown; in *b* the opposite pole of the nucleus becomes dissolved, showing that an astrosphere is active in its neighborhood, also. Temperature, 94° Fah.

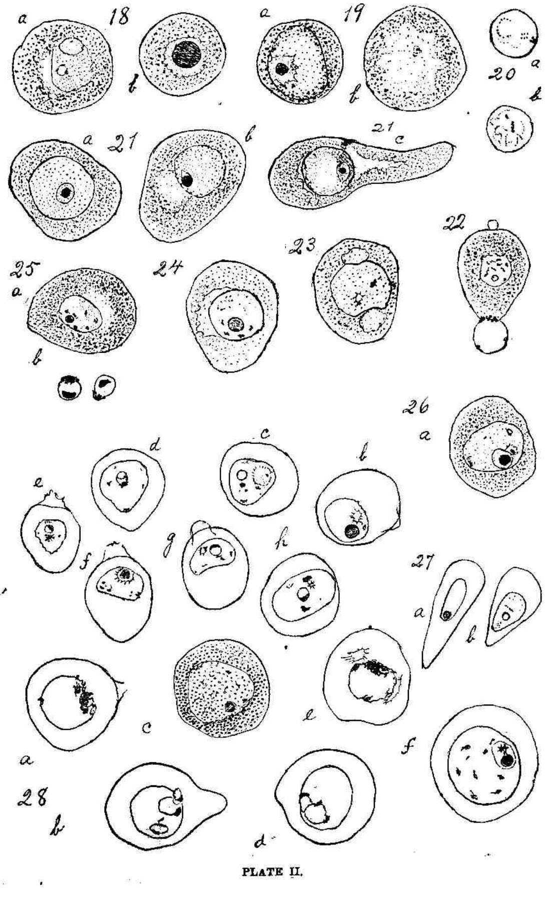

18
a
b
19
a
b
20
a
b
21
a
b
21 c
22
23
24
25
a
b
26
a
b
c
d
e
f
g
h
27
a
b
28
a
b
c
d
e
f

PLATE II.

EXPLANATION OF PLATE II.

OYSTER EGG BEFORE FERTILIZATION.

Fig. 18, *a b*. Eggs treated with iodine solution, stained and mounted, after lying four hours, unfertilized, in sea water. In *a* we see the nucleus beginning to break up; *b* is an exceptional and somewhat difficult case to explain. It is supposed the chromatin has diffused throughout the nucleolus and increased in amount at the same time; the latter body has swollen to an abnormal size.

Fig. 19, *a*, *b*. Same sort of eggs, prepared with formalin solution, after staining and mounting. In *a* the nuclear dissolution has hardly begun, while it is nearly completed in *b*.

Fig. 20. Two nuclei from eggs that have lain five hours in water, prepared with alcohol, stained with picro-carmine and mounted in balsam. Two sorts of chromatin bodies are present, viz., the beaded, bent threads and the large granules apparently definite in number, though it is difficult to determine just the exact number.

Fig. 21, *a*, *b*, *c* Three stained and mounted eggs prepared with iodine solution. These are eggs from a recently opened oyster, but the oyster has been out of water over night. This seems to increase the astrospheric protoplasm, as in *c*.

Fig. 22. Oyster egg, showing globules at both ends, probably consisting of astrospheric protoplasm. Egg had been treated with acetic acid under cover slip.

Fig. 23. Another egg, treated with acetic acid, showing shrinkage of nucleus at the poles next to astrospheric bodies. Oysters from which these eggs came had probably lain out of water awhile. Weather had been very hot.

Fig 24. Ordinary fresh oyster egg, treated with iodine and stained.

Fig. 25. Same sort of egg as last, treated with corrosive sublimate. At *b* are shown two nucleoli from other eggs, to show how there is an internal mass of chromatin imbedded in, and an external mass attached to, the hyaloplasmic body of the nucleolus.

Fig. 26, *a* to *h*. Various eggs, drawn without yolk granules, prepared with formalin and stained with picro-carmine. Only the more prominent and stainable grains of the nucleus are shown. The large, shadowy body in *c* is probably an astrospheric body, attached to the nucleus on the other side, though possibly it is the large nucleolus expanded and dissolving. Several of these eggs, as at *e* and *f*, show an extraordinary micropyle.

Fig. 27. "Formalin" eggs from oyster that has been some hours out of water.

Fig. 28, *a* to *f*. Eggs one and a half minutes after fertilization, treated with formalin, stained and mounted; *c* alone, drawn showing the yolk grains and the "reticulum" of the nucleus. This series should be compared with the last, and with figures of unfertilized eggs that have come from oysters that have not been freshly removed from the water or have lain several hours in water. It will be seen that the presence of the sperms, though they have not yet impregnated the eggs, has already caused interior activities in the nucleus. The chromatin bodies and nucleoli are rapidly dissolving. The astrospheres are developing and the walls of the nucleus in their neighborhood are breaking down with pseudopodic projections. There can hardly be a doubt but that some of the elements of the karyokinetic spindle, and possibly of the astrospheres, are derived from some of the chromatin bodies in the nucleus.

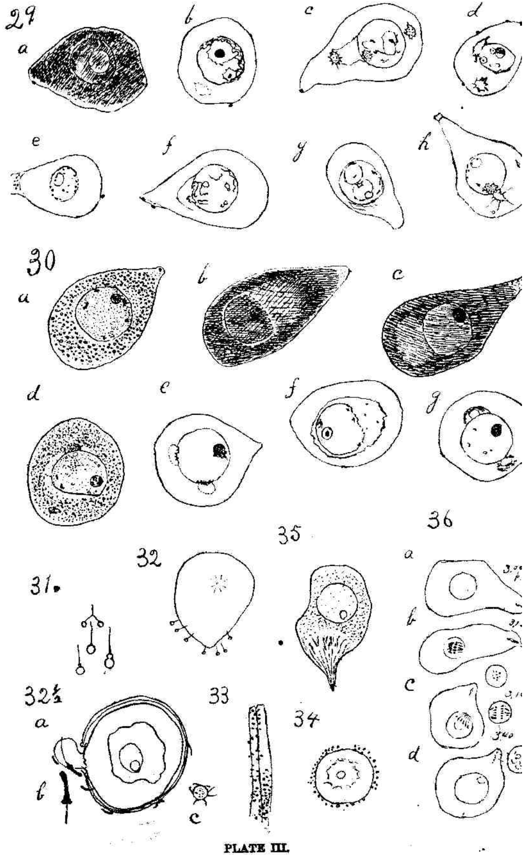


PLATE III.

EXPLANATION OF PLATE III.

OYSTER EGG DURING IMPREGNATION.

Fig. 29, *a* to *h*. Eggs one minute after fertilization; treated with corrosive sublimate; stained with picro-carmine; studied in balsam. In all, except *g* and *h*, one or more sperms are seen clinging to the surface. In *e* there is a wide micropylar funnel, and here many sperms have gathered. All the figures show that the nucleus is dissolving and the astrospheres are forming. In *c*, *d* two astrospheres are visible; in *a* and *e* none are seen. In the other figures one only is as yet present; *f* has probably the most advanced nucleus of the set.

Fig. 30, *a* to *g*. Similar eggs (as in 29) treated with iodine. The darkly shaded *b* and *c* figures illustrate the relative depth of staining; *d* exhibits the action of one of the centrosomes; in *e* and *g* the astrosphere has become two; in *b* and *c* we see the astrospheric protoplasm on different sides of the nucleus in the two cases; in *d* and *f* we see that at first this protoplasm forms a thin envelope around the nucleus on all sides. It looks as though we had to do with three parts to the astrosphere. Largest is the clear protoplasm; next is a nuclear sort of aggregate, and finally, a nucleolar point in the center, called the centrosome.

Fig. 31. Oyster sperms very greatly enlarged. In one of the specimens we see how the double-headed immature sperms split the flagellum, and so make two mature sperms.

Fig. 32. Illustrates how the pointed end of the egg offers the principal attraction for the sperms; also that the sperms attach themselves first by their tails.

Fig. 32½. Egg of a clam after fertilization. Owing to some abnormal condition, the egg has squeezed out a globule of very clear protoplasm at the micropyle, and the sperm that has attached here shows clearly its flagellum. In the other cases, only the heads are visible as comma-shaped bodies. At *b* one is drawn to a larger scale. At *c* is a small corpuscle, to which several sperms have attached.

Fig. 33. A couple of muscle fibers of the oyster, upon which many sperms have fastened. Treated with iodine, stained and mounted.

Fig. 34. An egg, as seen with a microscope, when the eggs are fertilized on the slide, and beneath a cover slip. After the proper lapse of time, nearly every egg, but with some exceptions, becomes covered with as many sperms as possible. We have here shown only the optical section.

Fig. 35. An egg in the act of receiving a sperm at the pointed end. The apical protoplasm is much clearer and freer from yolk grains than elsewhere, and it is evidently in some sort of kinetic action.

Fig. 36, *a* to *d*. The same egg viewed under the microscope, at different intervals following fertilization. The sperm is shown at the pointed end, and in *d* has broken up into chromosomes. Meanwhile, the egg chromosomes have been actively undergoing kinesis but in this case, probably from lack of oxygen under the cover slip, the kinesis is abortive, and no polar globules nor pronuclei were formed. To the right of *c* and *d* are shown three successive views of the nucleus. The uppermost one is a polar view.

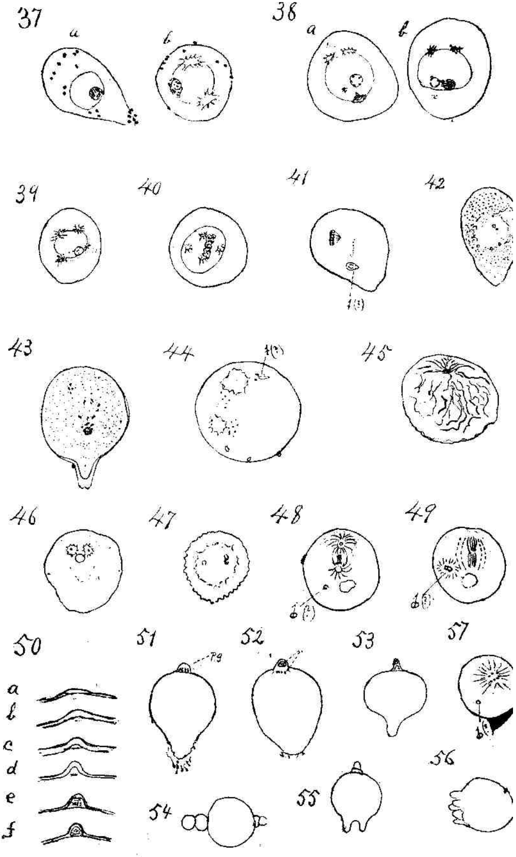


PLATE IV.

EXPLANATION OF PLATE IV.

FORMATION OF POLAR GLOBULES.

Fig. 37, *a* and *b*. Oyster eggs nine minutes after fertilization; stained; showing the sperms fastened upon various parts of the surface and particularly the point. In *b* we see the nucleolus dissolving, and find two astrospheres present. Unless otherwise stated, all eggs henceforth figured, were stained. *Those designated "living eggs" were, of course, not stained.*

Fig. 38, *a* and *b*. Similar eggs one minute later.

Fig. 39. Apparently, four astrospheres are present.

Fig. 40. The chromatin rosette has formed in the center of the nucleus, twelve minutes after fertilization.

Fig. 41. The chromatin rosette is traveling towards the surface of the broad end of the egg, twenty-two minutes after fertilization. Probably the body near the pointed end of the egg is the entered sperm.

Fig. 42 should have come before 40. It represents the nucleus dissolving, fifteen minutes after fertilization; the chromosomes are scattered as yet, and not gathered into a rosette.

Fig. 43. The chromosomes are collected into a ring. The astrospheres did not show in this specimen.

Fig. 44. Two sets of chromosomes, each with an astrosphere, are present. One or two other granules are shown, one of which is possibly the entered sperm. In that case the rosette nearest has relation to it rather than to the chromosomes. The chromosomes seem to be in groups similar to those in the nucleus before dissolution. Twenty minutes after fertilization.

Fig. 45. Egg 29 minutes after fertilization, stained after treatment with formalin. The clear protoplasm of the egg is present in branching and anastomosing plates that are much crinkled. Very difficult to represent in a drawing. Their number and course have been symbolized or shown diagrammatically by the lines. The middle of the broad pole of the egg is now drawn down into a pit.

Fig. 46. Shows the astrospheric spindle, with the chromatin nucleus lying between the astrospheres and near the surface of the egg, at its large end.

Fig. 47. Shows the living egg as soon as the sperm has entered, ten minutes after fertilization. The wall of the nucleus is dispersing and the chromatin nucleoli are dissolving. The egg-shell is being thrown into numerous wrinkles and the entire egg is contracting. It is at this time the condition of Fig. 45 is established. This condition remains until the egg has begun segmenting.

Fig. 48. Living egg five minutes later, showing the spindle which is to make the polar globules. It is a matter of doubt which of the two remaining bodies represents the entered sperm. Same doubt applies to the next figure.

Fig. 49. The polar spindle five minutes later. The central or chromosomic elements have separated into two groups. The upper one will form the first polar globule.

Fig. 50, *a* to *f*. Shows successive stages in the formation of the bud on the shell, to receive the first globule, containing, apparently, four pairs of chromosomes. These views are of the same egg, one minute apart, viewed alive.

Fig. 51. The egg with the first globule completed, forty minutes after fertilization. A new set of wrinkles now begin at the small end of the egg and travel or extend upwards. The material *of the second globule is being pushed out; this takes but a few minutes.*

Fig. 52. An egg with the second polar globule completed. Note that the chromosomes lie at the base of the bud containing the first globule, but this is not invariably the case in other eggs.

Fig 53. An egg with an extraordinarily prominent polar bud. The pointed end of this egg, instead of being drawn in so the egg can become nearly spherical, is being pushed out.

Fig. 54. An egg with two polar globules at each pole; the large globules at the small pole (left hand side) are not real polar globules, but are protoplasm or yolk plasm, squeezed out when the egg contracted, to make the real globules at the (in this figure) right-hand pole.

Fig. 55. Shows the two false polar globules side by side.

Fig. 56. While it has only one true polar globule, is budding a goodly group of false ones at the weak pole of the egg.

Fig. 57. An egg viewed from the pole while the polar spindle is active, making the polar globules. Just how many chromosomes there are, and just how they are divided to make the polar globules, has not been determined for the oyster egg. The phenomena are so very obscure as to baffle accurate observation, and the data from different eggs do not seem to agree, so far as careful observation has gone. Several independent counts of the chromosomes have given various numbers, but there has been most agreement on the number sixteen for the egg nucleus. *From general laws governing these procedures in other eggs, we should expect that the* first polar globule contains eight chromosomes and the second four. But as these chromosomes seem to pass from a state of subdivision to a state of union, and *vice versa*, constantly, it is no wonder that it is a difficult task to ascertain the exact number. When they are numerous they

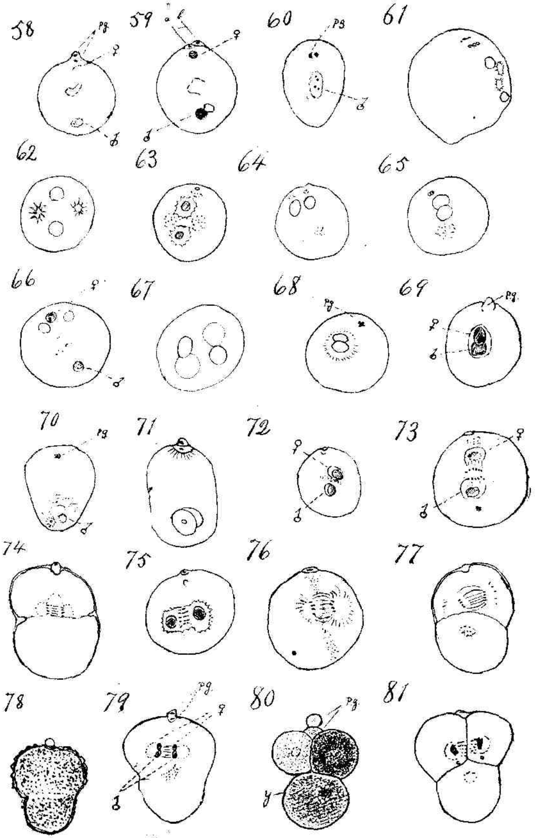


PLATE V.

EXPLANATION OF PLATE V.

UNION OF THE PRONUCLEI.

Fig. 58. Oyster egg twenty-five minutes after fertilization, stained with picro-carmine, showing the two polar globules, *P. g.* the female pronucleus (or rather its chromosomes), and the male pronucleus.

Fig. 59. Differs from the preceding only in that the chromatin of the female nucleus is diffused so that the two pronuclei are alike.

Fig. 60. Egg showing two polar globules and a nucleus having four chromosomes. This is either all derived from the sperm, in which case only one polar globule is as yet made or, as is less probable, each pronucleus has only two chromosomes at this stage. The nucleus alongside of the polar globule is half of the original egg nucleus. When it shall have given up half of its chromosomes, to form the second polar globule, it will be the female pronucleus.

Fig. 61. Showing the two pronuclei with their astrospheres. The other bodies in the egg are, presumably, polar globules, or their equivalent; perhaps the polar globules are hidden on the other side of the egg.

Fig. 62. The astrospheres have taken position, to draw the two pronuclei together.

Fig. 63. The two pronuclei are nearly in contact.

Fig. 64. Probably a variant of what is shown in 61.

Fig. 65. Shows an astrosphere splitting into two, close by the two pronuclei.

Fig. 66. Shows the female pronucleus with two astropheres; the male pronucleus has, as yet, apparently not developed any.

Fig. 67. Both pronuclei, each with an astrosphere in a peculiar stage, in which all four organs resemble each other in superficial appearance.

Fig. 68. The two pronuclei are enveloped by one mass of astrospheric protoplasm. The second polar globule alone is present, the first having been rubbed off.

Fig. 69. Same as 68, showing that the pronuclei are really nucleoli.

Fig. 70. Shows the sperm at the micropylar end of the egg, becoming furnished with an astrosphere. It is not plain whether or not the female pronucleus has come down here, too.

Fig. 71. Shows both pronuclei in close contact at the micropylar pole.

Fig. 72. Shows the two pronuclei dissolving, to make chromosomes.

Fig. 73. Shows the spindle and chromosomes of the pronuclei. New astrospheres will be developed on each side of the middle of the spindle, or else the spindle turns around and becomes the segmentation spindle. Compare Fig 63.

Fig. 74. The first segmentation spindle. Note that there are apparently three astrospheres; the fourth is hidden (perhaps lost) in the yolk hemisphere. Possibly it has something to do with separating the yolk from the germinal hemisphere.

Fig. 75. Segmentation spindle, 36 minutes after fertilization.

Fig. 76. The same, in the act of separating the egg into two segments. The chromosomes have separated, to form the daughter groups of chromosomes.

Fig. 77. Another egg, showing a marked division between the yolk and germinal portion of the egg. Same stage as Fig. 76.

Fig. 78. External view of a live egg during the process of starting division by the spindle, just *described. Note the wrinkles on the surface of the germinal hemisphere.*

Fig. 79. Optical section of such an egg after staining. Note that each daughter nucleus consists of two groups of chromosomes, diffused in a body of hyaloplasm. The bodies on the sides next the polar globules probably represent the two daughter halves of the female pronucleus, the others, similarly, of the male pronucleus. There seems to be some evidence of a "yolk nucleus," which is presumably the relic of one of the pronuclear astrospheres. It is hoped that the doubtful points will be cleared up by further studies.

Fig. 80. External view of a segmenting egg, one or two minutes later than Fig. 78. This is the stage of sharpest separation of the segmentation spheres or buds (blastomeres). Only two blastomeres are present, corresponding with the two daughter nuclei of 79. The yolk sphere (*y*) is the third sphere seen. It will soon reunite with the darker of the two blastomeres shown.

Fig. 81. Shows internal view, a very few minutes later, when the nucleus and spindle are passing into a resting condition, so that the blastomeres are closer together, but the yolk is still divided off by a line of separation.

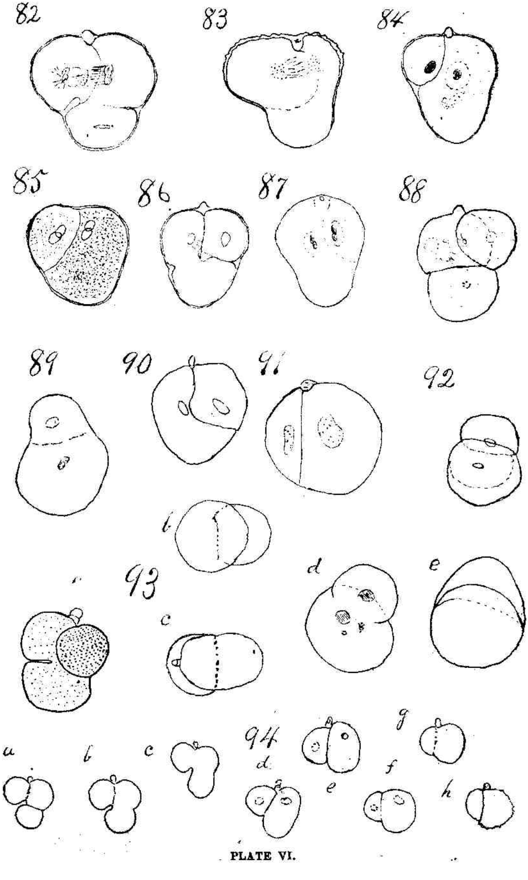


PLATE VI.

EXPLANATION OF PLATE VI.

OYSTER EGG DURING THE FIRST CLEAVAGE PERIOD.

Fig. 82. Shows the yolk sphere partly reunited to the macromere, the nucleus of which is passing to the resting stage. The nucleus in the micromere is still active, and its cell is sharply divided from the yolk.

Fig. 83. The yolk is now a part of the macromere, and the micromere is partly imbedded in it. The nuclei are nearly in the resting stage.

Fig. 84. The spindle has disappeared and the nuclei are in the resting condition.

Fig. 85. An egg like the last, showing that the micromere is clearer than the macromere.

Figs. 86, 87. Two views of eggs in stages corresponding to 84 and 85, but viewed from the other side.

Fig. 88. An oblique view of an egg nearly in stage, 83.

Figs. 89, 90, 91, 92. Eggs in various positions, and showing varieties of the "compact" form.

Fig. 93, *a* to *e*. Continuation of same subject as drawn from the living egg, and not so compact as in 89 to 92. Thus illustrating the contracting effect of the reagents.

Fig. 94, *a* to *h*. Views of one and the same egg, drawn while segmenting, and at intervals one minutes apart, beginning fifty-four minutes after fertilization, except *h*, which is five minutes later than *g*. Figure *a* is one minute after wrinkling.

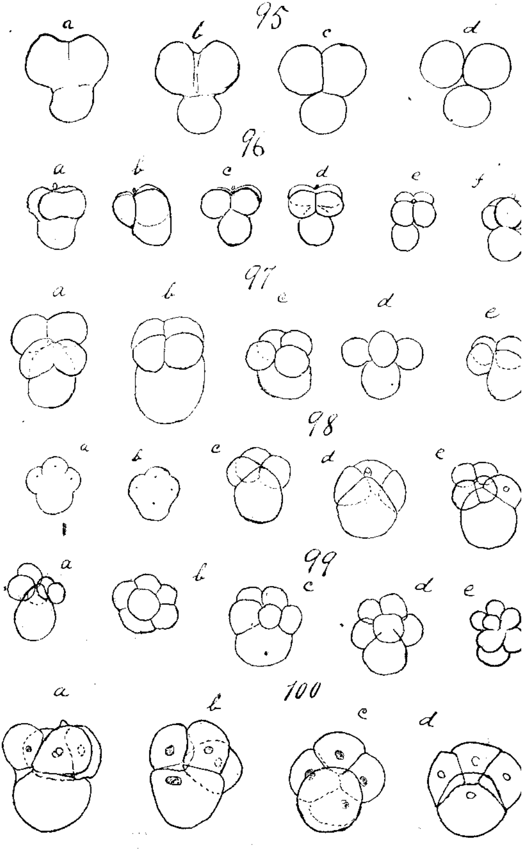


PLATE VII.

EXPLANATION OF PLATE VII.

OYSTER EGG DURING THE SECOND CLEAVAGE STAGE.

Fig. 95., *a* to *d*. Four stages in the formation of the first cleavage, that intervene between wrinkling and *a* of Fig. 94, when the development is slower, due to lower temperature. In 94 only about a minute elapsed after wrinkling, before form *a* was produced. In 95 the four stage are severally separated by one minute intervals.

Fig. 96, *a* to *f*. Stages in the execution of the second cleavage. The series follows *h* of Figs. 94, but were observed on another egg. Scarcely more than a minute separates these figures; *a* shows a view from the front, where the first micromere is situated. This has begun to elongate, and the top of the macromere behind it also elongates and separates off from the yolk; *b* shows the same stage from the side; *c* is a side view; *d* is a front view and *e* a later, side view *f* is an oblique view. It will be seen that apparently four micromeres are formed.

Fig. 97, *a* to *e*. Various eggs in various positions during this stage of development. In *d* and *e* one of the apparent new micromeres has joined the yolk, to make a new macromere.

Fig. 98, *a* to *e*. Various stages of compacting of these new blastomeres; *a* and *b* fit on to the series in 96; *e* shows a case of delayed division of the first macromere, while the other, not only divided in the second cleavage, but its daughter cells have begun to divide again. Such a case gives a stage with five nuclei in five blastomeres.

Fig. 99, *a* to *d*. Various eggs with five blastomeres, viewed in various positions: *a* from side; *b* from below; *c* from side; *d* from in front.

Fig. 99, *e*. Shows an egg with six blastomeres. This is the case when the first micromere divides twice and the first macromere divides but once, the former having passed the third cleavage plane while the latter only the second. Note that these the first three cleavage planes are approximately perpendicular to one another.

Fig. 100, *a* to *d*. From stained and mounted specimens, corresponding to the preceding series, which were observed in the living, active eggs. Drawings in Fig. 100 represent a magnification of 500 diameters, whereas Figs. 95–99 only 250 to 350 times. Were it not for the shrinkage produced by mounting, the drawings in Fig. 100 would be twice the diameter of the other figures.

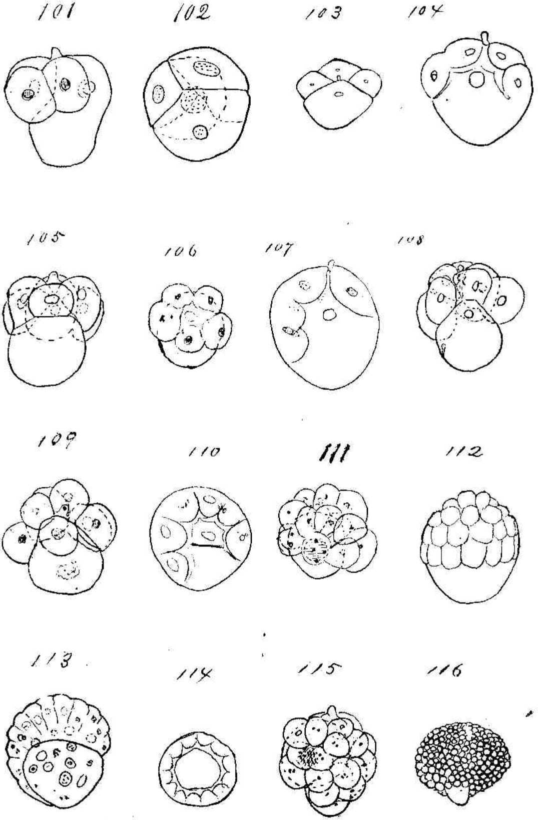


PLATE VIII.

EXPLANATION OF PLATE VIII.

OYSTER EGG DURING THE LATER SEGMENTATION STAGES.

Fig. 101. Side view of stained egg after the macromere has re-formed, after the second cleavage.

Figs. 102 and 103. The four blastomeres have become compact.

Fig. 104. Stage with five blastomeres.

Fig. 105 Front view of egg, with six blastomeres.

Fig. 106. Top view of same.

Fig. 107. Optical section of same after compacting.

Fig. 108. Hind (?) view of developmental stage, with eight blastomeres.

Fig. 109. Egg one and a half hours after fertilization, showing the micromeres beginning to envelop the macromere.

Fig. 110. Optical section at a slightly later stage.

Fig. 111. The macromere is nearly enveloped by micromeres, which meanwhile are multiplying and becoming smaller.

Fig. 112. Only one side of the micropylar pole is left uncovered.

Fig. 113. Optical section at a slightly later stage (from side), one and three-fourths hours after fertilization. The nuclei, seen apparently in the macromere, are those of the cells or blastomeres in the side walls projected.

Fig. 114. Horizontal optical section, a little later (compact).

Fig. 115. The macromere is nearly covered.

Fig. 116. Embryo three hours after fertilization of egg.

PART II. CONTRIBUTIONS TO OUR KNOWLEDGE OF BOVINE TUBERCULOSIS.

In this part of the report of the Biologist we present the observations made upon the College Farm herd and the Hospital Barn herd, in continuation of our previous reports on these animals. The findings at the autopsies of two interesting cases are described, a table of abortions, and one of special tests with tuberculin, are given; and finally, an extended and careful set of temperature readings, from February to June, inclusive, observed on tuberculous animals and their calves, concludes this report.

A careful and detailed study of these data and discovery of principles is reserved for future reports.

AUTOPSY OF NO. 18.

This cow had heen tested four times. The first time, on admission to the herd, October 26th, 1898. The highest temperature before injection was 102.5°; the highest the next day was 102.5°. As she was young, a high normal temperature was expected, and she was admitted. Of course, the temperature record gave absolutely no evidence of reaction having occurred.

The second test was made October 19th, 1900. The highest tbe first day was 102.3°, the next day the temperature rose to 105.9°. Clearly a reaction.

The third test was applied April 24th, 1901. The highest the first day was 103.0°—a suspicious "fever temperature." Next morning following the test the temperature was 106.0° and remained high all day. A very clear case of reaction.

Again, she was tested June 15th, 1901. Her normal temperature was now 103° to 104°, or even higher. Next day, after injection of tuberculin, the temperature was the same. The figures show no "test" reaction, but we must consider the high normal temperature as a physical symptom of advancing tuberculosis.

During the hot weatber of June, 1901, this animal failed rapidly, and it was determined to slaughter her. This was done, and autopsy made July 6th. Her appearance at this time was typical of the last stages of tuberculosis.

It was distressing to observe her wasted and delicate form, resem-

bling cases of human consumption. Post-mortem examination showed nothing abnormal in the udder, nor were there tubercles in the liver nor on the intestines, except in the mesenteric lymph glands, many of which were enlarged, and some were caseated. All were imbedded in superabundant fat.

In the chest cavity we found pleural adhesions of the lungs and the serous linings of lungs and chest, studded with masses of millet-seed tubercles. All the pulmonary glands were enlarged, caseated and filled with innumerable small foci of the lesions of tuberculosis. The largest mediastinal gland was nearly a foot in length. Both lungs were nearly solid, filled with masses and foci of tubercles, more or less caseated. In the left lung only the cephalic lobe was functional, but it, too, contained several tuberculous foci at the edge. The surface of the posterior lobe was marbled.

In the right lung, nearly the whole of the middle lobe was functional, but congested. The rest of the lung was solid tubercle. This case of rapid consumption contrasts greatly with the next.

AUTOPSY OF NO. 59.

This cow, one of the three surviving members of the old herd, proved tuberculous in 1894, at the age of seven years. She has been tested twenty times, during the seven years she lived since that date, giving a marked reaction, more frequently, when tested, than any of the other members of the tuberculous herd of the hospital barn. She died August 28th, of enfeebled vitality, due to combined old age and disease. She stood up until within two days of her demise. She had nursed continually a young bull-calf, her own, horn the preceding February.

The writer was away at the time of her death, and the lungs, liver and other viscera were kept three days, immersed in a formalin solution, before they were examined, August 31st. At that date decomposition was rank in the interior of all the organs, and there was so much discoloration, it was difficult to form an opinion as to the true condition of the organs at the time of death. The lungs were heavily engorged with blood, and there was evidence of other lung disease than tuberculosis.

But there were tubercles also. In the posterior apex of the right lung (posterior lobe) was an indurated area three inches in diameter, containing a caseous cavity, breaking up into pus. A large area of

similar nature occupied the anterior and external portion of the same lobe. No other tubercles were found. The temperature record of this cow from February to June is shown in the following tables, and shows that she was subject to great fluctuations in her temperature, frequently breaking out into fever periods. At her nineteenth test, March 22d, she gave a reaction rise of one degree. At the twentieth test, June 15th, when there had been naturally a series of fever reactions, she failed to respond to the test. It is presumed that the heat of the summer, combined with her enfeebled condition and the strain of supporting her calf, were the immediate cause of death.

She certainly showed a comparatively limited area invaded by tubercle, not sufficient of itself to cause death; yet she had been *emaciated for many months and showed the consumptive appearance.*

The calf was tested at the same time as tbe mother, but it seems not to have caught the disease, and probably no tubercle germs were passed from this cow.

She offered a typical case of "slow consumption," in sharp contrast to No. 18. How far the numerous injections of tuberculin retarded the progress of the disease cannot be judged. It will require a special experiment on a large number of reacting animals, in similar physical condition, separating them into two groups, one to receive no injections, while the cows of the other group receive a various number of injections—the experiment extended for years—to give a proper answer to a question of this kind. Such an experiment can only be carried out by special legislative action, particularly as regards the expense.

REMARKS ON THE TABLES.

The first table exhibits the record of abortions, showing that they were not so frequent during the past year as previously. It is not certain to what cause this decrease is due. Further consideration of this subject is postponed until such time as the data we have accumulated shall be sufficiently abundant for study. The herd has been treated for a protracted time with injections of iodo-phenol. In some other herds this remedy has apparently given good evidence of being a specific cure.

Next follows a table of individual special temperature records, at different dates, and finally, a very extended series of temperature observations on the members of the hospital herd, including

three calves,* introduced into this barn and fed the milk, to see whether (and how soon) the power to react is developed and whether or not the conditions with this tuberculous "hospital herd" are favorable to infection.

So far as we have the evidence, it does not at present point to the conclusion that the conditions offered in this barn are infectious. This does not prove that they would not be infectious in any other case. The evidence is negative and is not so valuable as positive evidence.

The temperature record is a part of a series which we hope to work up in the future, relative to the external influences that modify the temperature of animals.

The following abbreviations have been used :

L. Cow lying down.	O. Cow is or has just been running out in the yard.
R. Cow has just risen.	r. Cow arose some minutes ago.
S. Cow standing.	o. Old thermometer.
F. Cow feeding.	n. New thermometer.
W. Cow has been watered recently.	

Wherever it is not specified, the following routine applies to the feeding and watering of this herd :

7 A. M. Fed.
8 A. M. Milked.
12 M. Fed; let out to water (1 P. M. on Sundays).
1 P. M. Returned to barn (2 P. M. on Sundays).
5 P. M. Fed; then milked.

As usual, when giving extended tables of temperatures, in all cases (except Table IV.) where the temperature exceeds 100° only the excess is given.

Leaders (. . . . . .) indicate omission of observations at hours due. Dash (———) indicates a longer period of rest from observing.

* Two of these calves were the offspring of members of the tuberculous herd.

TABLE III.*

Record of Abortions in College Herd, November, 1900—November, 1901.

COWS.	Stall.	Age—years.	Date of purchase.	Date of service.	Date of abortion.	Months of pregnancy.	Previous service of bull. Cow.	Previous service of bull. Date.	Vitality of calf.
No. 21	21	5	Oct. 3, 1899.	Nov. 15, 1900.	May 13, 1901.	6	Sebolt.	Nov. 15, 1900.	Alive; died.
Regena, 3d	26	3	Raised.	Feb. 27, 1901.	May 31, 1901.	8	Sebolt, 2d.	Mar. 26, 1901.	Dead.
Princessa (fifth time)	30	5	Sept. 22, 1896.	Dec. 28, 1900.	June 28, 1901.	6	No. 14.	Nov. 28, 1900.	Alive; died.
No. 4.	4	8	Nov. 3, 1898.	Jan. 10, 1901.	July 15, 1901.	6⅛	B. B. Heifer.	Jan. 17, 1901.	Alive; died.
Elixir	31	12	Sept. 22, 1896.	Jan. 25, 1901.	Aug. 1. 1901.	6¼	B. B. Cow.	Jan. 22, 1901,	Dead.

*Observed and recorded by C. B. Lane.

TABLE IV.

Special Tests.

Animal	Lillith.	Myrtle.	Roseolas.	Guernsey Bull.	Raritan Cow.	No. 18.	96's Calf.	14's Calf.
Number of test	1st.	1st.	1st.	3d.	?	3d.	3d.	3d.
Date	Oct. 7, 1900.	Oct. 7, 1900.	Oct. 7, 1900.	Feb. 19, 1901.	Apr. 24, 1901.	Apr. 24, 1901.	July 15, 1901.	July 15, 1901.
Previous test	....	....	....	Nov. 5, 1900.	......	Oct. 19, 1900.	June 15, 1901.	June 15, 1901.
Hours	Injection made at 5 P. M.							
4 P. M.	....	....	....	102.2	102.0	101.5	....	....
5 "	101.7	101.6	101.7	102.0	101.2	101.3	102.8	103.0
6 "	103.0	102.4	102.3	101.7	101.5	102.5	103.3	103.4
7 "	102.6	102.1	102.1	101.0	101.4	101.2	103.6	103.5
8 "	102.4	101.6	102.0	100.6	101.2	102.0	104.0	103.6
9 "	102.2	101.4	101.9	101.6	101.3	102.2	104.0	103.5
10 "	102.1	101.3	102.0	101.0	101.3	103.0	103.7	103.6
5 A. M.	101.2	101.6	100.7	101.6	101.5	106.0	103.6	102.0
6 "	101.3	101.1	101.4	....	....	....	....	....
7 "	101.7	101.8	102.0	....	101.3	104.6	....	....
8 "	101.4	101.0	101.9	101.8	102.0	103.9	102.1	101.8
9 "	101.5	101.0	101.6	101.6	101.1	104.0	102.2	101.8
10 "	102.8	101.8	101.7	102.0	101.0	104.2	102.4	102.0
11 "	102.3	101.6	101.6	102.0	100.8	105.0	102.3	102.0
12 M.	102.1	101.8	101.5	101.7	101.5	105.0	102.8	102.2
1 P. M.	101.1	101.4	101.8	101.7	100.6	105.1	102.4	102.0
2 "	102.0	101.8	101.5	102.0	101.3	104.8	102.8	102.1
3 "	102.0	101.4	102.0	101.5	100.9	104.0	102.8	102.4
4 "	102.0	101.5	101.7	101.6	101.5	103.7	102.5	102.4
5 "	102.0	101.6	101.8	101.4	100.7	100.3	102.6	102.2
6 "	102.5	101.8	102.0	101.6	101.2	100.8	102.5	102.2
						Reacts.		

TABLE V.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
February 22—							
11 A. M.	102.3	100.8	100.9	100.8	102.6	102.4	.....
12 (M.	2.5	0.9	0.6	1.0	2.5	2.3	.....
1 P. M.	3.9	0.7	99.8	99.9	2.8	2.4	.....
2 "	1.8	1.6	0.8	1.8	2.4	2.7	.....
3 "	1.9	1.1	0.7	1.9	2.9	2.6	.....
4 "	2.0	1.2	0.4	1.9	2.7	2.9	.....
5 "	2.0	0.9	0.9	2.1	2.7	3.0	.....
6 "	2.6	0.7	1.2	2.4	3.2	3.2	.....
7 "	2.0	1.4	1.0	2.0	3.3	2.9	.....
8 "	2.2	1.3	1.3	1.7	3.5	2.7	.....
9 "	2.3	1.3	1.0	1.8	2.8	2.7	.....
10 "	.....	.....	.....	.....	.....	.....	.....
11 "	.....	.....	.....	.....	.....	.....	.....
February 23	.....	.....	.....	.....	.....	.....	.....
4 A. M.	1.8	99.8	0.5	1.0	2.3	2.2	.....
5 "	1.7	0.5	1.0	1.2	2.6	1.6	.....
6 "	1.2	1.2	0.6	1.0	2.3	1.6	.....
7 "	1.2	99.2	1.5	1.7	2.2	2.1	.....
8 "	1.2	0.7	1.6	1.6	2.6	2.2	.....
9 "	1.1	0.9	1.2	1.9	1.9	2.2	.....
10 "	1.0	1.6	1.4	1.8	1.9	2.1	.....
11 "	0.9	1.2	0.6	1.3	2.0	1.8	.....
12 M.	1.3	1.6	1.4	2.2	2.7	1.7	.....
1 P. M.	1.0	1.5	1.4	2.0	1.7	2.3	.....
2 "	98.6	0.4	0.7	99.4	1.9	2.3	.....
3 "	98.8	0.5	0.3	98.5	2.1	2.2	.....
4 "	0.5	99.4	0.7	99.2	2.2	2.9	.....
5 "	1.1	0.9	1.3	0.5	2.3	3.9	.....
6 "	1.8	1.1	1.0	0.6	3.2	2.5	.....
7 "	1.2	1.0	0.7	0.8	2.2	2.4	.....
8 "	0.8	98.6	0.8	0.2	2.6	2.8	.....
9 "	1.0	99.7	0.7	1.0	2.6	2.3	.....
10 "	99.8	99.6	0.0	0.4	2.7	2.1	.....
11 "	0.7	0.3	1.2	0.8	1.6	2.5	.....
12 Midnight	0.2	98.8	1.2	0.6	1.8	2.0	.....
February 24—							
1 A. M.	0.5	93.8	1.2	1.3	2.3	2.6	.....
2 "	0.0	97.8	1.0	0.0	2.0	2.7	.....
3 "	0.8	0.0	1.0	0.2	2.6	2.2	.....
4 "	.....	.....	.....	.....	.....	.....	.....
5 "	2.6	98.1	1.2	0.9	2.4	1.7	.....
6 "	1.8	0.4	1.2	1.1	2.2	2.1	.....
7 "	1.6	0.3	1.4	0.8	1.7	2.3	

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
February 24—							
8 A. M.	1.8	0.7	1.7	1.3	1.6	1.8	....
9 "	0.9	0.9	1.6	1.0	2.3	2.7	....
10 "	1.6	1.4	1.2	1.6	2.0	2.7	....
11 "	1.9	1.5	1.3	2.0	2.8	2.0	....
12 M.	2.0	2.0	1.1	1.8	1.3	2.4	....
1 P. M.	0.1	0.6	0.8	0.0	0.6	2.1	....
2 "	99.7	0.3	0.9	99.7	2.0	2.9	....
3 "	99.8	0.7	1.0	0.3	2.2	2.6	....
4 "	1.2	99.2	0.9	0.8	1.7	2.9	....
5 "	1.7	0.3	1.3	1.4	1.8	2.7	....
6 "	0.5	0.8	1.2	1.3	3.2	4.0	....
7 "	R. 98.6	R. 97.6	0.2	0.5	2.2	3.2	....
8 "	1.2	r. 99.2	0.9	0.7	2.4	3.4	....
9 "	0.9	S. 99.1	1.0	1.0	2.8	3.3	....
10 "	....	....	....	....	....	....	....
March 1—							
4 P. M.	1.1	3.3	0.6	1.8	1.7	3.7	....
5 "	F. 1.4	1.1	1.1	2.1	3.0	3.5	....
6 "	R. 1.8	R. 0.8	R. 1.5	R. 1.5	2.8	3.8	....
7 "	R. 1.0	R. 3.7	R. 0.5	R. 1.4	3.4	3.7	....
8 "	1.5	R. 0.1	99.9	R. 1.8	2.5	4.5	....
9 "	2.2	99.3	0.0	1.5	2.9	4.1	....
10 "	R. 1.3	R. 0.8	R. 0.7	R. 1.6	2.4	3.9	....
11 "	1.7	R. 99.3	R. 0.2	R. 1.5	2.4	4.1	....
12 Midnight	R. 2.0	R. 99.9	R. 0.9	R. 1.4	2.3	4.2	....
March 2—							
1 A. M.	1.8	R. 99.7	R. 0.2	1.4	1.9	4.9	....
2 "	R. 1.9	R. 99.4	R. 0.1	R. 1.1	1.6	4.0	....
3 "	R. 1.4	L. 99.1	R. 99.8	R. 1.0	2.2	3.7	....
4 "	R. 1.0	R. 98.9	1.1	1.2	2.0	3.0	....
5 "	1.9	R. 98.2	0.0	1.3	2.0	3.5	....
6 "	R. 2.2	0.5	R. 0.4	1.5	2.0	3.0	....
7 "	2.5	1.0	0.6	1.8	2.0	2.5	....
8 "	1.3	R. 99.5	0.2	1.8	2.0	2.6	....
9 "	R. 2.1	1.3	0.6	1.8	2.0	2.7	....
10 "	R. 2.6	R. 0.4	R. 0.5	1.5	1.5	2.9	....
11 "	1.7	1.4	0.9	1.8	0.8	2.7	....
12 M.	R. 1.3	R. 99.8	R. 1.5	2.0	1.8	2.7	....
1 P. M.	0.8	1.5	1.7	0.7	2.0	2.3	....
2 "	0.1	1.9	1.9	1.2	2.2	2.6	....
3 "	0.9	1.7	1.4	1.1	2.8	3.2	....
4 "	0.8	R. 0.0	0.5	1.0	2.6	3.0	....
5 "	0.9	1.3	0.6	1.3	2.7	3.1	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
March 2—							
6 P. M.	1.7	1.1	0.7	1.4	2.4	2.8	....
7 "	R. 1.2	R. 99.1	R. 99.8	0.8	2.9	3.0	....
8 "	R. 1.9	R. 98.8	99.6	R. 0.8	2.4	2.4	....
9 "	R. 1.8	R. 0.1	R. 1.0	R. 0.5	2.6	2.2	....
10 "	1.4	R. 0.6	0.9	0.6	2.6	2.7	....
11 "	R. 99.4	R. 99.0	R. 0.9	0.6	2.4	2.8	....
12 Midnight	1.9	0.8	1.0	0.3	2.3	2.2	....
March 3—							
1 A. M.	1.5	0.6	1.2	0.5	2.6	2.3	....
2 "	1.0	R. 99.7	R. 0.8	0.4	2.5	2.3	....
3 "	1.0	99.7	1.0	0.9	2.0	1.7	....
4 "	R. 0.9	99.9	R. 1.2	0.7	2.2	2.2	....
5 "	1.0	0.2	R. 1.3	0.4	1.5	1.7	....
6 "	1.0	0.7	1.0	0.5	2.0	2.3	....
7 "	0.1	0.6	1.5	0.7	1.8	1.9	....
8 "	1.4	0.5	1.2	0.7	1.4	2.0	....
9 "	2.1	0.6	1.6	0.5	0.2	2.2	....
10 "	1.6	1.1	1.1	1.4	1.8	2.3	....
11 "	1.4	1.1	1.2	1.4	2.1	2.2	....
12 M.	1.4	1.4	1.4	1.8	2.6	2.7	....
1 P. M.	1.5	1.8	1.2	1.9	L. 2.0	L. 2.3	....
2 "	1.4	1.7	2.1	1.3	1.8	L. 2.4	....
3 "	1.5	1.8	1.3	1.9	L. 2.0	L. 2.2	....
4 "	1.1	R. 99.4	R. 1.5	0.7	2.3	3.1	....
5 "	1.9	0.0	1.5	0.7	2.5	2.7	....
6 "	R. 99.8	R. 0.8	1.2	0.3	2.6	3.0	....
7 "	1.0	0.1	1.1	1.0	2.2	3.0	....
8 "	1.6	1.3	1.1	1.6	2.6	3.0	....
9 "	1.2	1.0	0.5	1.0	2.6	2.9	....
10 "	1.4	99.9	0.6	1.4	2.6	2.8	....
11 "	1.6	0.5	0.6	1.4	2.6	2.7	....
12 Midnight	....	....	....	....	....	....	....
March 4	....	....	....	....	....	....	....
3 A. M.	1.6	99.6	0.6	1.4	2.8	2.3	....
4 "	1.7	0.1	0.8	1.0	2.1	2.0	....
5 "	1.7	R. 99.8	R. 0.1	2.0	1.9	1.9	....
6 "	1.2	0.2	R. 99.4	1.8	1.8	1.9	....
7 "	1.5	1.5	0.9	1.6	2.1	2.0	....
8 "	....	....	....	....	....	....	....
March 8—							
4 P. M.	n. 0.8 o. 0.8	0.7	1.1	1.5	2.6	2.8	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
March 8—							
5 P. M.	1.5	1.7	1.2	2.2	3.6	2.5	....
6 "	1.6	1.7	1.8	2.0	3.0	2.9	....
7 "	n. 1.1 o. 1.6	n. 1.5 o. 1.3	0.3	n. 2.0 o. 1.8	n. 2.1 o. 2.3	n. 2.2 o. 1.8	....
8 "	1.6	0.4	0.8	1.2	2.5	2.7	....
9 "	1.3	0.8	0.0	1.0	2.2	2.4	....
10 "	0.5	0.4	0.5	0.3	2.5	2.2	....
11 "	0.6	0.2	99.6	0.6	2.4	2.2	....
12 Midnight	0.8	0.8	0.6	0.5	2.4	2.2	....
March 9—							
1 A. M.	1.2	0.4	0.2	0.6	2.0	1.8	....
2 "	0.4	0.6	0.2	0.2	2.0	2.0	....
3 "	0.6	99.6	0.0	0.4	2.0	1.6	....
4 "	1.0	0.3	0.1	0.6	2.2	1.8	....
5 "	1.5	99.8	0.0	0.5	1.5	1.8	....
6 "	1.2	99.4	0.7	1.0	1.4	1.5	....
7 "	1.4	0.9	0.7	1.5	1.9	2.4	....
8 "	1.9	1.1	1.3	2.1	1.6	1.6	....
9 "	1.5	0.9	R. 0.4	1.7	1.6	2.2	....
10 "	1.3	1.5	1.0	1.6	1.5	2.0	....
11 "	2.0	0.6	R. 0.5	1.6	1.7	1.5	....
12 M.	1.8	0.2	1.0	1.3	1.5	1.5	....
1 P. M.	1.7	0.7	1.0	1.6	1.8	1.7	....
2 "	0.5	1.5	0.9	1.8	1.6	2.0	....
3 "	99.4	1.5	1.6	1.5	2.5	2.5	....
4 "	0.0	0.4	1.7	1.7	2.1	2.7	....
5 "	1.0	1.3	1.2	1.4	2.6	2.6	....
6 "	1.4	1.6	0.7	1.6	2.3	2.4	....
7 "	1.3	1.6	0.8	1.2	2.8	2.4	....
8 "	1.2	0.8	• 1.2	1.3	2.6	2.6	....
9 "	R. 1.4	R. 0.1	0.0	1.0	2.5	2.6	....
10 "	R. 1.2	R. 0.2	R. 1.1	R. 0.8	2.6	2.3	....
11 "	1.8	R. 99.4	99.4	0.4	2.3	2.2	....
12 Midnight.*	0.1	0.3	0.5	0.8	2.8	1.9	....
March 10—							
1 A. M.	1.3	0.5	0.7	0.4	2.4	2.1	....
2 "	R. 1.2	R. 0.6	0.9	0.9	2.0	2.3	....
3 "	R. 0.4	R. 0.4	1.8	0.8	2.8	2.1	....
4 "	1.2	99.6	R. 99.6	0.0	2.3	2.5	....
5 "	R. 0.9	99.6	0.4	99.5	2.2	2.0	....
6 "	0.2	R. 99.8	1.1	0.3	2.2	1.6	....
7 "	0.8	1.2	0.8	0.7	1.8	1.8	....
8 "	1.0	0.8	0.6	1.6	2.8	2.6	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
March 10—							
9 A. M.	0.2	1.2	1.3	1.8	1.8	2.2	
10 "	1.6	1.5	0.7	1.9	1.8	2.0	
11 "	1.8	1.2	1.2	1.6	2.1	1.5	
12 M.	0.2	1.1	1.2	1.6	1.9	1.9	
1 P. M.	1.0	1.2	0.8	1.5	2.8	2.7	
2 "	1.0	0.7	1.2	1.8	2.2	2.8	
3 "	W. 98.9	0.4	0.8	99.3	n. 1.9 o. 1.4	2.5	
4 "	n. 99.2 o. 99.0	0.0	0.8	98.7	1.7	2.2	
5 "	99.4	1.0	1.1	99.2	2.2	2.4	
6 "	n. 98.6 o. 98.0	1.4	0.7	99.8	2.4	2.2	
7 "	0.0	99.9	1.1	99.9	2.2	2.3	
8 "	n. 0.4 o. 0.7	99.8	0.8	99.8	2.6	2.6	
9 "	0.2	98.6	R. 0.9	R. 98.7	2.6	2.4	
10 "	0.2	99.2	0.2	R. 98.9	2.2	2.4	
11 "	0.2	R. 98.6	0.2	0.5	1.9	2.3	
12 Midnight	0.6	0.0	0.0	1.3	2.5	2.3	
March 11—							
1 A. M.	0.4	99.7	0.2	99.4	2.6	2.0	
2 "	0.0	98.8	0.2	99.0	2.0	1.8	
3 "	99.9	n. 98.3 o. 98.0	0.7	0.1	2.2	2.1	
4 "	0.6	98.6	0.2	0.0	2.3	1.1	
5 "	99.8	98.6	0.5	0.5	2.2	1.8	
6 "	0.1	99.2	99.6	0.8	2.8	1.4	
7 "	0.8	99.3	0.6	1.6	2.0	1.1	
March 15—							
4 A. M.	0.4	1.4	1.0	1.0	2.2	2.1	
5 "	0.5	0.8	1.1	2.0	2.6	3.0	
6 "	1.2	1.0	1.5	2.0	2.8	2.8	
7 "	2.4	1.7	1.1	1.6	2.2	2.6	
8 "	0.4	99.5	98.7	1.0	2.0	2.0	
9 "	0.8	99.6	0.5	1.2	2.1	2.8	
10 "	1.1	0.5	0.0	0.7	1.9	2.8	
11 "	0.3	99.6	99.7	0.5	1.7	2.0	
12 Midnight	99.8	99.3	99.7	0.8	1.8	1.8	
March 16—							
1 A. M.	0.9	98.2	99.5	0.8	2.0	2.2	
2 "	0.7	99.7	0.2	1.3	2.0	2.1	
3 "	1.0	0.2	0.7	1.4	2.0	2.2	
4 "	1.2	98.3	0.2	1.2	2.0	2.3	

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	
1901.							
March 16—							
5 A. M.	0.7	99.1	98.8	1.6	1.8	1.6	....
6 "	0.2	99.8	0.4	1.4	1.9	1.7	....
7 "	99.8	0.6	0.4	1.6	1.7	1.7	....
8 "	0.5	0.1	0.7	1.5	1.7	1.7	....
9 "	1.3	0.6	99.9	1.4	2.3	2.8	....
10 "	1.4	R. 0.6	1.0	1.7	2.1	2.2	....
11 "	1.3	1.2	1.1	1.5	2.0	2.1	....
12 M.	1.4	1.0	1.8	1.8	1.2	1.5	....
1 P. M.	1.6	1.2	1.1	1.6	2.2	1.8	....
2 "	0.2	0.5	0.7	1.3	1.5	2.1	....
3 "	99.6	1.0	99.6	1.3	2.1	2.3	....
4 "	0.8	1.2	0.6	1.1	2.3	2.3	....
5 "	1.9	0.4	1.1	1.0	2.1	2.6	....
6 "	1.3	1.3	1.3	1.3	2.1	2.4	....
7 "	1.0	1.0	0.7	1.8	1.2	2.6	....
8 "	1.2	99.9	99.9	1.3	1.8	2.1	....
9 "	1.0	99.8	0.0	0.6	2.0	1.9	....
10 "	*0.8*	*0.2*	*0.7*	R. *0.7*	2.3	1.9	....
11 "	R. 0.9	R. 0.0	0.4	R. 0.5	1.6	2.8	....
12 Midnight	99.1	98.0	99.4	99.7	2.1	1.4	....
March 17—							
1 A. M.	0.5	98.4	0.6	99.8	1.7	1.8	....
2 "	0.8	99.4	0.8	1.0	2.0	1.6	....
3 "	1.2	*0.5*	*0.8*	*0.7*	2.2	1.5	....
4 "	99.7	98.7	0.7	99.6	1.9	1.6	....
5 "	0.2	98.9	0.8	0.0	2.0	1.2	....
6 "	0.1	98.0	0.5	0.6	1.6	1.1	....
7 "	0.0	99.2	0.7	0.9	1.9	1.4	....
8 "	0.9	0.4	1.0	1.2	1.9	1.9	....
9 "	1.1	99.2	0.9	1.0	1.8	1.8	....
10 "	1.8	0.2	1.0	1.0	1.8	2.7	....
11 "	1.8	1.5	1.4	1.7	1.7	1.6	....
12 M.	1.8	1.2	1.2	2.0	2.2	1.9	....
1 P. M.	1.9	2.0	1.6	2.1	2.4	2.3	....
2 "	1.7	1.8	1.2	1.2	1.2	2.0	....
3 "	0.6	R. 0.6	R. 99.3	R. 0.5	2.0	2.0	....
4 "	99.8	1.0	0.9	0.7	2.0	2.2	....
5 "	0.5	0.2	0.4	1 2	2.5	3.1	....
6 "	1.3	0.8	0.5	1.1	2.4	2.8	....
7 "	1.1	1.1	0.5	0.8	2.5	2.8	....
8 "	0.4	R. 99.8	0.6	0.6	1.8	2.2	....
9 "	0.7	99.8	0.8	1.0	2.2	2.2	....
10 "	0.2	1.0	1.0	0.8	1.6	2.0	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
March 17—							
11 P. M.	99.7	1.0	0.8	0.9	1.6	2.0	......
12 Midnight	......	......	......	......	......	......	......
Minims inje'd at 6 P. M.	80	93	75	60	7	14	80
March 22—							
4 P. M.	1.3	1.0	1.4	1.5	1.8	2.4	......
5 "	1.0	1.1	1.5	1.8	2.0	2.0	......
6 " (Injected)	1.6	1.2	1.7	1.8	2.6	2.6	......
7 "	1.2	1.2	1.8	1.6	3.3	3.8	3.4
8 "	0.7	0.2	1.5	1.0	2.5	2.5	......
9 "	0.4	0.5	1.3	0.6	2.8	2.6	2.9
10 "	0.4	0.8	1.2	1.2	2.4	2.0	......
11 "	0.8	0.6	0.7	1.7	1.8	1.9	2.6
12 Midnight	0.3	1.0	2.4	1.1	2.4	2.0	2.8
March 23—							
1 A. M.	R. 1.0	R. 1.0	R. 2.3	0.1	2.0	1.7	......
2 "	0.7	1.0	2.4	1.0	2.6	1.7	2.7
3 "	......	......	......	......	......	......	......
4 "	0.7	0.3	3.0	0.4	1.5	2.0	2.6
5 "	0.3	1.4	3.4	0.7	1.8	0.7	2.7
6 "	1.8	1.2	3.6	0.2	1.9	1.0	2.4
7 "	1.0	1.3	3.1	99.9	O. 0.4	1.0	......
8 "	1.6	1.7	3.0	0.7	2.0	2.4	1.9
9 "	1.8	1.9	2.9	1.4	2.8	2.0	2.2
10 "	1.6	2.8	3.6	1.8	2.0	2.1	......
11 "	1.4	3.0	2.8	2.9	2.0	2.0	2.0
12 M.	2.6	2.8	3.3	2.5	2.2	1.8	2.0
1 P. M.	2.4	2.6	3.6	3.0	2.2	1.7	2.0
2 "	1.7	2.7	2.9	3.0	2.2	1.8	2.1
3 "	2.4	2.4	2.6	3.2	1.9	1.8	......
4 "	3.1	1.5	1.2	3.6	2.5	1.8	2.5
5 "	2.5	1.4	1.7	4.0	2.8	1.9	2.1
6 "	1.9	1.1	1.3	4.0	2.0	2.3	......
7 "	2.2	1.0	1.2	3.9	2.5	3.3	2.4
8 "	1.7	0.4	0.2	3.5	2.7	2.9	2.2
9 "	1.9	99.8	0.9	3.6	3.3	2.2	2.8
10 "	L. 0.2	L. 0.0	0.2	3.0	2.6	2.2	1.5
11 "	L. 0.2	99.5	0.3	2.2	2.3	2.0	2.8
12 Midnight	S. 99.5	98.2	0.0	1.8	1.8	1.5	2.3
March 24—							
1 A. M.	0.2	99.8	0.7	1.3	1.7	1.4	2.2
2 "	0.8	98.5	99.6	1.0	1.7	1.2	1.7
3 "	0.0	98.6	99.8	0.4	1.7	0.5	2.1
4 "	0.5	98.7	0.8	0.7	2.1	0.7	1.6

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
March 24—							
5 A. M.	0.5	98.5	99.5	0.8	1.5	0.6	1.6
6 "	0.3	0.4	99.9	1.3	2.0	1 0	1.5
7 "	1.0	99.2	0.0	0.9	2.0	0.7	....
8 "	0.8	0.8	99.6	0.9	1.7	0.9	2.0
9 "	1.2	0.5	99.5	1.0	2.0	2.1	1.4
10 "	1.6	0.7	99.8	1.8	1.6	1.2	2.1
11 "	2.1	1.0	1.0	1.9	1.7	1.2	1.8
12 M.	1.5	0.1	0.7	1.5	1.5	1.9	....
1 P. M.	1.7	0.9	1.2	0.0	1.2	1.5	1.8
2 "	0.0	0.3	1.3	0.2	1.2	1.6	....
3 "	1.1	99.3	1.2	99.6	1.6	1.8	2.4
4 "	1.6	0.3	1.3	0.3	1.8	1.3	2.2
5 "	1.2	R. 99.5	R. 1.0	R. 0.4	2.0	1.7	2.2
6 "	1.0	0.0	1.0	0.8	1.9	1.7	2.4
7 "	1.5	0.4	1.2	1.3	2.2	2.2	2.6
8 "	1.7	99.8	0.1	1.2	2.7	2.2	2.5
9 "	1.4	0.0	0.4	0.6	2.2	2.2	....
10 "	1.3	99.6	0.7	99.8	2.2	2.3	2.6
11 "	0.8	0.8	1.0	0.0	2.3	1.9	....
12 Midnight	1.2	R. 98.8	0.2	0.6	1.2	1.5	2.4
March 25—							
1 A. M.	1.0	98.4	0.8	0.8	1.9	1.8	2.3
2 "	0.6	0.2	99.0	99.4	2.2	1.9	2.0
3 "	0.4	98.6	0.0	0.3	2.0	1.7	....
4 "	....	....	....	....	....	....	....
5 "	0.3	98.1	0.4	0.2	1.7	1.2	2.0
6 "	*0.5*	*99.4*	*0.3*	*0.4*	*1.6*	*1.6*	*1.8*
7 "	0.3	0.7	0.5	0.1	2.0	1.4	2.7
8 "	0.2	0.8	99.6	0.7	2.2	1.4	....
March 29—							
3 P. M.	0.7	0.8	1.1	1.6	2.0	1.8	1.9
4 "	1.4	0.8	1.2	2.0	3.8	1.8	2.6
5 "	1.3	0.7	1.3	1.4	O. 2.8	2.0	2.2
6 "	1.0	0.7	1.1	1.8	2.5	2.6	2.1
7 "	99.9	99.8	0.8	1.4	2.0	2.5	2.4
8 "	99.5	99.7	99.9	0.8	2.2	1.8	2.1
9 "	0.7	0.0	1.2	0.6	2.1	1.9	2.0
10 "	1.0	0.5	2.0	0.3	1.9	1.6	2.0
11 "	0.4	99.8	0.9	0.3	1.9	1.9	1.8
12 Midnight	0.5	99.7	0.0	0.3	1.8	1.5	2.1
March 30—							
1 A. M.	....	....	....	....	....	....	....
2 "	0.2	97.8	1.2	0.2	1.4	1.4	2.0

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
March 30—							
3 A. M.	....	....	....	....	....	....	....
4 "	0.4	98.4	99.3	99.8	1.8	1.0	1.6
5 "	0.7	99.0	0.3	0.3	1.7	0.7	1.7
6 "	0.0	99.3	0.8	0.2	1.4	0.2	1.4
7 "	0.2	99.8	0.3	1.2	1.0	1.5	....
8 "	0.2	0.2	1.0	1.6	1.6	0.8	1.4
9 "	0.4	0.8	99.8	1.8	1.4	1.0	1 6
10 "	1.0	0.8	1.0	1.6	1.1	0.8	1.6
11 "	1.6	1.0	1.0	1.7	1.2	1.7	1.5
12 M.	0.0	0.9	0.5	1.2	1.0	0.8	1.4
1 P. M.	1.2	0.6	0.7	1.6	1.5	0.9	1.7
2 "	1.2	0.8	0.6	2.0	1.6	2.0	2.0
3 "	0.7	0.9	1.4	1.6	1.5	1.6	....
4 "	1.4	0.7	1.3	1.1	1.8	2.0	1.8
5 "	1.0	0.5	0.8	0.8	1.9	1.8	2.0
6 "	1.3	0.7	0.7	1.3	2.4	2.4	1.8
7 "	1.9	99.0	0.7	0.4	2.3	2.5	....
8 "	0.8	0.2	1.2	1.0	2.3	2.2	2.0
9 "	0.7	99.6	0.7	99.9	2.0	1.7	2.1
10 "	0.1	99.3	0.7	0.4	1.6	1.9	1.8
11 "	1.0	98.2	1.0	0.5	1.8	2.1	....
12 Midnight	0.2	99.2	0.6	0.2	2.3	1.7	1.3
March 31—							
1 A. M.	1.4	98.8	0.8	99.8	1.2	1.5	....
2 "	1.0	98.2	0.6	0.0	1.7	1.6	1.5
3 "	0.8	99.0	0.5	0.0	1.6	1.3	1.4
4 "	0.6	98.8	0.5	99.5	1.4	1.3	2.1
5 "	0.3	97.3	0.6	99.8	1.8	0.5	1.7
6 "	98.6	98.8	0.4	0.0	1.4	1.0	1.6
7 "	1.8	98.8	0.0	0.7	1.5	1.0	1.5
8 "	99.9	99.2	0.6	0.4	1.7	2.1	2.1
9 "	0.8	99.5	0.6	1.8	1.5	1.6	1.8
10 "	1.3	0.6	1.0	1.6	1.6	1.9	1.6
11 "	0.4	0.6	1.0	1.6	1.6	1.4	1.7
12 M.	1.5	0.5	1.0	1.8	1.4	1.5	1.7
1 P. M.	0.2	0.6	1 2	1.4	1.4	1.3	....
2 "	1.6	1.3	0.7	1.3	1.6	1.6	1.7
3 "	1.5	0.6	0.2	0.7	1.7	1.9	....
4 "	1.8	0.5	0.2	0.7	2.1	1.9	2.5
5 "	1.0	0.1	0.7	0.8	2.8	1.7	2.0
6 "	2.0	0.6	0.6	1.2	2.4	2.2	2.3
7 "	1.5	0.7	0.7	0.5	2.5	1.9	2.5

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
March 31—							
8 P. M.	1.3	0.2	0.6	0.4	2.7	2.5	2.3
9 "	0.8	0.4	0.3	0.7	2.6	2.4	2.3
10 "	1.0	0.4	0.7	0.2	2.1	2.3	2.0
11 "	0.0	98.8	0.1	99.7	2.6	1.8	....
12 Midnight	99.7	98.9	0.4	99.8	2.4	1.6	1.7
April 1—							
1 A. M.	....	....	....	....	....	....	....
2 "	1.4	98.4	0.6	99.0	2.3	1.6	1.6
3 "	0.6	98.6	0.8	99.9	2.1	1.4	1.6
4 "	1.8	99.4	0.3	0.3	2.1	1.2	1.6
5 "	0.0	99.6	0.7	99.8	1.6	1.0	0.2
6 "	0.6	99.6	9.5	99.8	1.5	0.3	1.1
7 "	0.4	0.2	1.0	0.9	1.4	0.5	....
8 "	2.0	0.7	0.8	0.6	0.6	0.6	1.5
9 "	1.5	1.4	0.9	1.4	1.7	0.5	1.3
10 "	2.8	1.5	0.9	1.4	1.2	1.2	1.5
11 "	1.9	1.7	0.7	1.6	1.3	2.0	2.0
12 M.	2.1	1.3	0.9	1.8	1.3	1.6	1.9
1 P. M.	3.0	0.8	0.4	1.3	1.3	1.4	....
2 "	2.2	0.3	1.3	1.4	1.6	1.5	1.3
3 "	1.7	1.5	1.4	1.6	2.1	1.7	1.9
4 "	1.2	0.7	1.2	1.0	2.3	1.4	1.9
5 "	2.7	1.1	1.2	1.6	2.7	2.6	2.6
6 "	2.1	1.2	1.2	1.8	2.0	1.8	....
7 "	2.2	1.4	1.4	1.8	2.2	2.2	2.1
8 "	4.0	0.7	1.4	1.0	2.0	1.9	2.2
9 "	4.5	99.0	1.0	0.7	1.8	1.9	2.1
10 "	4.6	0.6	0.8	0.3	1.9	2.0	2.2
11 "	4.0	0.6	0.6	0.8	2.0	2.0	....
12 Midnight	2.4	98.9	0.5	99.3	1.6	1.5	1.9
April 2—							
1 A. M.	3.4	99.3	0.9	99.7	1.7	1.6	1.9
2 "	2.5	99.4	0.5	99.4	2.0	1.5	1.6
3 "	2.0	99.9	0.6	99.4	1.8	1.3	1.7
4 "	....	....	....	....	....	....	....
5 "	2.0	98.8	0.4	0.0	1.6	0.7	1.2
6 "	0.8	99.1	99.7	99.7	1.2	1.0	2.0
7 "	1.8	0.1	0.6	0.6	1.8	1.4	1.4
8 "	....	....	....	....	....	....	....
April 7—							
1 A. M.	....	....	....	....	....	....	....
2 "	....	....	....	....	....	....	....
3 "	2.4	97.9	0.7	1.0	1.3	1.3	2.1

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
April 7—							
4 A. M.	2.1	0.6	0.4	1.8	0.8	1.2	1.8
5 "	1.4	0.3	0.8	1.2	1.1	1.1	1.5
6 "	3.2	0.0	1.0	0.9	0.9	1.2	1.5
7 "	3.3	99.8	1.0	0.8	0.9	1.1	1.7
8 "	2.9	0.3	0.2	0.4	1.7	0.5	....
9 "	3.7	1.0	1.8	1.5	1.3	1.8	2.1
10 "	W. 99.8	W. 99.8	W. 0.6	W. 97.8	0.8	2.3	1.4
11 "	98.5	0.6	0.2	97.8	1.2	1.8	1.6
12 M.	98.6	99.6	0.6	97.6	1.2	1.5	1.4
1 P. M.	99.7	0.2	0.2	97.0	1.0	1.7	1.5
2 "	0.4	99.8	0.5	98.8	0.9	1.5	1.4
3 "	0.6	0.0	1.2	98.6	1.6	1.4	1.7
4 "	1.6	99.4	1.0	99.8	1.3	1.6	1.9
5 "	2.0	0.0	0.4	0.1	1.9	1.9	....
6 "	3.7	1.0	0.6	1.3	2.8	2.4	0.3
7 "	4.0	0.9	0.5	1.4	1.9	1.4	2.2
8 "	2.5	0.5	1.0	0.6	1.6	2.8	1.9
9 "	3.6	99.6	0.9	1.0	1.5	1.5	2.1
10 "	3.7	99.4	1.7	1.0	1.9	1.4	1.6
11 "	3.6	99.3	1.0	1.0	1.8	1.3	....
12 Midnight	2.5	0.0	1.0	0.5	1.4	1.5	2.0
April 8—							
1 A. M.	....	....	....	....	....	....	....
2 "	1.8	99.8	0.5	99.9	1.0	1.0	1.4
3 "	1.5	99.2	1.0	99.8	0.9	1.0	1.4
4 "	1.6	0.0	0.9	0.0	1.0	0.6	1.8
5 "	2.0	0.0	0.7	0.6	0.5	0.6	....
6 "	2.7	99.6	0.7	0.0	0.7	0.8	0.8
7 "	2.5	0.7	0.9	0.6	1.4	0.6	....
8 "	2.5	1.0	0.5	0.7	0.9	0.9	1.3
9 "	2.5	1.5	1.4	1.2	1.2	2.3	....
10 "	3.8	1.2	....	....	....	....	....
11 "	n. 3.7	n. 2.6	n. 1.6	n. 2.1	n. 1.5	n. 1.6	n. 2.0
12 M.	4.0	2.8	1.6	2.8	1.5	1.6	2.3
1 P. M.	3.5	1.8	1.8	2.5	1.4	1.4	1.4
2 "	3.8	2.9	2.4	1.4	1.5	1.4	1.4
3 "	W. 1.7	W. 2.6	W. 0.5	0.0	1.7	1.7	2.0
4 "	1.2	2.6	0.6	99.3	1.8	2.2	1.8
5 "	1.3	2.2	0.6	99.5	2.2	2.0	2.2
6 "	1.3	3.0	1.0	1.8	2.5	2.0	....
7 "	2.6	3.0	1.0	1.4	2.5	2.0	2.3
8 "	....	....	....	....	....	....	....
9 "	n. 3.8	n. 1.8	n. 1.2	n. 1.2	n. 1.8	n. 1.5	n. 1.6

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
April 8—							
10 P. M.	3.0	1.0	0.8	0.8	1.8	1.3	2.0
11 "	3.0	2.0	1.0	1.0	1.5	1.4	2.0
12 Midnight	......	......	......	......	......	......	......
April 9—							
1 A. M.	3.2	0.2	1.0	0.6	0.8	1.4	1.4
2 "	3.0	0.4	0.3	0.4	0.8	1.0	1.7
3 "	......	......	......	......	......	......	......
4 "	2.0	0.5	0.5	0.3	0.9	0.0	1.4
5 "	2.0	0.4	99.9	0.4	0.6	0.2	......
6 "	2.2	99.0	0.4	99.5	0.4	0.3	1.0
7 "	3.0	0.3	0.8	0.8	0.6	0.2	......
8 "	2.4	0.3	0.7	0.5	0.8	0.4	1.0
9 "	2.8	0.8	0.8	1.7	1.8	1.0	1.7
10 "	2.0	1.0	1.4	2.5	1.4	0.8	1.4
11 "	2.8	0.6	1.0	2.6	1.3	1.2	1.6
12 M.	2.8	1.0	1.4	2.4	1.4	1.4	1.8
1 P. M.	3.4	99.8	1.0	2.0	1.2	1.0	1.4
2 "	3.9	0.6	1.4	2.4	1.6	1.4	1.8
3 "	2.9	0.0	0.3	0.1	1.9	1.7	2.1
4 "	2.8	99.0	0.7	0.2	2.0	2.0	......
5 "	2.5	0.2	0.5	0.2	2.6	2.5	2.7
6 "	2.4	0.0	0.5	1.0	2.6	2.4	2.6
7 "	3.6	0.2	0.9	1.6	2.4	1.9	2.5
8 "	3.8	0.6	0.6	0.5	2.2	2.0	2.4
9 "	3.0	99.0	1.0	0.3	2.2	1.9	......
10 "	......	......	......	......	......	......	......
11 "	2.0	99.0	0.9	0.5	1.9	1.4	1.4
12 Midnight	3.3	99.2	0.8	0.5	1.5	1.3	1.6
April 10—							
1 A. M.	3.7	99.6	1.4	0.5	1.8	1.8	1.8
2 "	3.0	99.7	1.9	0.6	1.8	0.8	......
3 "	3.2	98.6	1.0	0.6	1.4	1.0	1.7
4 "	2.2	99.7	1.2	0.5	1.0	0.9	1.2
5 "	3.0	99.6	0.6	0.3	1.2	0.5	......
6 "	3.6	99.4	0.7	0.3	1.0	0.3	0.4
7 "	3.8	98.9	1.0	1.6	1.0	0.6	1.0
8 "	3.4	99.7	0.6	0.6	1.3	0.8	1.2
9 "	......	......	......	......	......	......	......
April 12—							
12 Midnight	99.0	0.9	99.7	1.9	0.9	1.9	......
April 13—							
1 A. M.	99.9	99.9	99.5	99.4	1.0	1.2	2.0

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
April 13—							
3 A. M.	99.4	99.8	99.8	0.2	0.9	1.5	1.2
4 "	0.6	0.2	0.3	99.4	0.8	1.0	1.6
5 "	......	......	......	......	......	......	......
6 "	99.8	98.8	99.5	0.5	0.9	1.2	1.5
7 "	0.0	99.6	0.2	0.0	1.0	0.5	......
8 "	0.7	0.1	0.0	0.3	1.6	1.0	2.0
9 "	0.9	0.0	0.8	0.0	1.5	1.8	1.8
10 "	1.2	0.4	0.6	0.2	1.1	1.6	2.4
11 "	1.8	0.4	0.5	1.9	1.8	1.7	......
12 M.	1.6	1.0	0.8	1.9	1.6	2.0	1.6
1 P. M.	1.6	1.5	0.6	2.2	1.5	2.0	......
2 "	1.7	1.3	1.2	1.9	1.6	2 0	1.7
3 "	1.5	0.9	1.0	2.0	1.7	1.9	......
4 "	2.0	2.0	1.2	1.7	1.2	2.2	2.0
5 "	2.0	2.2	1.0	2.0	2.0	2.5	......
6 "	2.0	2.6	1.3	1.5	1.4	1.6	2.4
7 "	1.8	1.9	1.4	1.6	2.4	2.2	......
8 "	2.2	R. 2.2	2.2	1.0	2.7	1.8	2.4
9 "	1.1	R. 0.5	0.6	0.2	2.6	1.9	......
10 "	......	......	......	......	......	......	......
11 "	......	......	......	......	......	......	......
12 Midnight	1.7	1.0	0.7	0.0	0.9	1.6	1.9
April 14—							
1 A. M.	......	......	......	......	......	......	......
2 "	0.4	99.7	0.4	99.7	1.5	1.4	1.8
3 "	0.3	0.0	99.7	0.3	1.6	1.5	2.0
4 "	0.1	0.0	99.9	99.8	1.5	1.0	......
5 "	1.1	0.0	0.3	0.2	1.3	1.1	1.5
6 "	99.8	1.6	0.0	0.0	1.3	0.7	......
7 "	0.7	1.0	0.3	99.7	1.2	0.8	1.6
8 "	0.7	1.8	0.0	0.4	1.8	1.4	......
9 "	1.0	1.7	0.0	99.8	1.8	1.1	2.0
10 "	1.6	1.5	0.3	99.2	1.2	1.6	......
11 "	0.0	0.8	0.0	99.1	1.1	1.7	1.5
12 M.	99.8	0.5	0.5	99.9	1.5	1.2	......
1 P. M.	99.6	0.9	0.4	0.1	1.5	1.3	1.4
2 "	99.4	1.2	99.4	0.6	1.8	1.8	......
3 "	0.4	1.2	0.6	0.2	1.9	2.1	2.3
4 "	99.6	0.5	0.4	0.2	2.2	2.4	......
5 "	0.2	1.3	0.3	1.0	2.4	2.2	2.7
6 "	1.8	1.6	0.2	1.8	2.6	2.5	......
7 "	2.2	2.1	1.2	1.5	2.6	2.9	2.7
8 "	2.0	0.3	1.5	0.7	2.4	2.1	......

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
April 14—							
9 P. M.	......	......	......	......	......	......	......
10 "	1.4	1.6	1.0	0.2	2.2	2.3	2.1
11 "	......	......	......	......	......	......	......
12 Midnight	......	......	......	......	......	......	......
April 15—							
1 A. M.	0.8	2.0	99.6	99.9	1.6	2.8	2.8
2 "	......	......	......	......	......	......	......
3 "	0.6	2.4	1.0	99.3	1.6	1.7	2.0
4 "	0.4	1.7	1.0	99.8	1.0	1.6	......
5 "	0.2	1.9	1.3	99.9	0.6	1.6	2.0
6 "	R. 0.4	R. 1.5	1.0	99.6	1.7	1.1	......
7 "	......	......	......	......	......	......	......
April 20—	Rainy.	Stalls	damp.				Eye hurt.
2 P. M.	0.5	99.6	99.5	1.0	1.9	2.2	4.0
3 "	0.7	99.8	1.3	1.1	1.7	3.1	4.6
4 "	99.3	99.6	1.0	0.6	......	2.7	......
5 "	2.2	99.7	0.6	0.3	2.4	2.4	4.7
6 "	2.2	99.5	1.8	1.3	2.3	2.5	......
7 "	2.0	0.5	1.0	1.3	2.6	2.7	5.0
8 "	2.1	1.2	1.6	1.1	2.4	2.8	......
9 "	......	......	......	......	......	......	......
10 "	1.5	0.5	1.0	0.8	2.2	2.5	4.8
11 "	......	......	......	......	......	......	......
12 Midnight	2.1	99.6	0.9	98.6	1.3	2.4	4.2
April 21—							
1 A. M.	1.5	0.7	0.7	0.2	2.4	2.0	4.3
2 "	......	......	......	......	......	......	......
3 "	0.7	0.8	0.6	0.5	1.6	2.0	4.0
4 "	1.4	99.9	0.8	99.3	1.1	2.4	......
5 "	1.0	0.3	99.8	0.4	1.4	1.4	3.2
6 "	1.9	0.6	0.5	0.0	0.5	1.4	3.6
7 "	1.5	0.6	0.4	0.9	1.9	0.4	3.8
8 "	1.6	1.0	1.0	0.9	2.0	1.6	......
9 "	1.6	1.0	0.6	0.8	1.8	1.4	3.7
10 "	2.4	1.0	1.5	1.8	1.9	1.7	......
11 "	2.4	0.2	1.4	1.2	1.6	1.8	3.2
12 M.	1.7	1.1	1.0	1.8	2.2	2.2	4.5
1 P. M.	2.1	99.5	1.1	1.8	2.2	2.2	4.6
2 "	1.4	0.7	1.5	1.8	2.1	2.0	4.5
3 "	0.1	0.7	0.9	0.6	2.2	2.1	4.0
4 "	0.8	0.1	1.6	0.9	1.7	2.6	4.5
5 "	1.0	0.3	1.7	1.4	2.0	2.6	3.9
6 "	99.6	0.5	1.6	1.5	2.6	2.1	......

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of M.	Extra Calf.
1901.							
April 21—							
7 P. M.	1.3	0.9	0.5	0.2	2.6	2.8	4.2
8 "	0.0	0.8	1.6	0.7	2.1	2.0	1.0
9 "	1.4	0.6	0.8	0.9	2.7	1.7	1.5
10 "	....	....	....	....	....	....	....
11 "	2.0	99.7	0.5	0.2	2.0	1.8	3.5
12 Midnight	1.0	0.4	1.0	0.9	2.0	1.7	....
April 22—							
1 A. M.	0.9	0.4	1.0	0.9	2.3	1.5	3.9
2 "	....	....	....	....	....	....	....
3 "	1.7	99.7	0.9	99 9	2.8	1.4	2.5
4 "	1.2	0.4	1.0	0.2	1.4	1.2	3.0
5 "	1.6	0.1	0.6	99.7	1.8	1.0	2.8
6 "	0.9	0.1	1.0	0.1	1.2	1.1	3.1
7 "	1.8	0.3	0.8	0.4	1.7	0.8	4.2
8 "	....	....	....	....	....	....	....
April 27—							
2 P. M.	1.1	0.4	1.5	1.3	1.5	2.3	....
3 "	1.5	0.6	0.5	1.6	1.6	2.4	....
4 "	1.6	99.9	0.9	1.6	1.8	2.4	....
5 "	1.2	0.6	1.0	1.5	1.8	2.5	....
6 "	1.7	0.7	0.9	1.8	2.4	2.6	....
7 "	2.0	1.0	1.0	1.1	2.3	2.7	....
8 "	1.6	0 6	1.8	1.2	2.2	2.5	....
9 "	1.2	0.3	1.2	1.0	1.7	2.5	....
10 "	1.0	0.4	1.0	1.3	0.7	1.0	....
11 "	n. 1.2	n. 0.4	n. 0.9	n. 0.7	2.1	2.2	....
12 Midnight	2.8	0.4	1.1	0.5	2.0	2.0	....
April 28—							
1 A. M.	0.2	99.7	0.7	0.3	2.0	2.0	....
2 "	1.0	0.8	0.7	0.4	1.4	2.6	....
3 "	0.9	99.9	1.0	99.8	1.3	1.4	....
4 "	0.5	99.9	0.6	0.4	1.3	1.8	....
5 "	1.2	0.3	0.4	99.9	1.3	1.4	....
6 "	99.5	99.6	1.1	0.2	0.5	1.1	....
7 "	99.5	99.5	0.0	0.5	1.2	1.0	....
8 "	1.2	99.5	0.0	0.6	2.8	1.3	....
9 "	2.0	0.5	0.8	1.2	1.8	1.2	....
10 "	1.6	0.1	0.5	1.6	1.6	1.4	....
11 "	2.6	0.7	0.7	1.5	1.3	1.4	....
12 M.	2.2	0.6	1.2	1.6	1.2	1.9	....
1 P. M.	2.0	0.7	0.7	1.0	1.4	2.4	....
2 "	0.7	0.9	0.7	0.8	1.7	1.9	....
3 "	0.2	1.6	0.6	0.8	2.0	2.1	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	Extra Calf.
1901.							
April 28—							
4 P. M.	0.2	1.3	0.3	0.7	1.9	2.4	....
5 "	1.5	1.4	0.3	1.1	2.0	2.4	....
6 "	2.0	1.9	1.3	1.6	2.3	2.5	....
7 "	2.1	2.0	1.0	1.4	2.5	2.6	....
8 "	1.1	1.7	1.6	1.3	2.0	2.5	....
9 "	1.4	1.3	1.1	0.6	1.9	2.2	....
10 "	1.0	2.0	1.3	0.7	1.9	2.2	....
11 "	0.6	0.6	1.4	0.0	2.0	2.0	....
12 Midnight	1.0	0.8	1.2	0.2	2.0	1.4	....
April 29—							
1 A. M.	0.2	0.0	1.0	99.4	1.5	1.4	....
2 "	1.2	0.7	1.2	99.8	1.6	1.4	....
3 "	0.2	0.6	1.2	99.7	1.7	2.2	....
4 "	1.2	0.3	0.5	99.8	2.1	1.0	....
5 "	0.3	0.3	0.5	99.8	1.6	0.9	....
6 "	0.3	99.4	0.7	0.0	1.5	0.8	....
7 "	0.7	0.1	0.6	99.7	1.5	1.0	....
8 "	....	....	....	....	....	....	....
May 5—							No. 18.
4 A. M.	0.5	99.2	0.3	0.4	0.0	0.5	98.8
5 "	0.2	0.1	0.6	99.8	1.8	1.5	0.7
6 "	99.8	99.8	99.7	0.2	1.9	1.4	0.3
7 "	0.3	0.5	99.5	99.9	1.0	1.5	0.5
8 "	0.7	0.7	1.0	0.2	1.4	1.4	0.8
9 "	1.5	1.0	0.8	1.0	1.9	1.9	1.7
10 "	2.0	1.2	1.0	1.4	1.7	2.0	2.2
11 "	2.2	1.2	1.5	1.4	1.6	1.8	1.7
12 M.	1.8	1.3	0.6	1.5	1.6	1.8	1.8
1 P. M.	1.4	1.4	1.2	2.2	1.8	2.2	1.9
2 "	1.4	1.1	0.9	1.6	1.5	2.2	2.5
3 "	1.3	0.5	1.0	1.6	1.6	1.7	2.7
4 "	1.3	0.9	0.8	1.1	1.6	2.0	2.9
5 "	1.9	1.9	1.8	1.9	2.2	2.3	2.9
6 "	1.0	1.2	1.3	1.6	1.7	2.5	2.7
7 "	1.2	1.0	1.0	1.7	1.6	2.7	2.4
8 "	0.8	1.7	1.7	1.7	2.2	2.4	2.4
9 "	....	....	....	....	....	....	....
10 "	1.4	0.8	1.1	99.7	1.2	2.2	1.7
11 "	....	....	....	....	....	....	....
12 Midnight	1.2	99.7	1.0	99.7	1.0	1.8	0.8
May 6—							
1 A. M.	99.6	0.8	0.9	99.8	1.5	1.6	0.6
2 "	0.0	1.2	1.2	99.0	0.6	1.8	0.9

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1901.							
May 6—							
3 A. M.	99.6	99.7	0.2	99.0	1.4	1.4	0.5
4 "	98.6	99.9	0.2	98.2	0.8	1.3	1.0
5 "	99.6	0.3	0.7	98.6	1.0	1.1	0.8
6 "	98.4	1.0	0.0	98.7	1.4	1.4	0.8
7 "	0.4	0.9	0.0	99.8	....	....	0.4
8 "	....	....	....	....	....	....	....
May 11—							
6 P. M.	1.6	1.8	0.4	1.4	2.0	2.2	1.8
7 "	1.4	1.6	0.8	1.0	2.2	2.4	1.6
8 "	0.9	1.1	0.6	0.6	2.2	2.5	1.4
9 "	1.5	1.2	1.0	1.2	2.2	2.6	1.2
10 "	0.9	0.7	0.9	0.4	2.0	2.2	0.8
11 "	....	....	....	....	....	....	....
12 Midnight	1.0	99.3	0.6	99.3	2.0	1.1	1.2
May 12—							
1 A. M.	1.6	0.4	0.6	0.2	1.6	2.0	1.1
2 "	0.8	0.7	0.2	0.3	1.1	1.7	1.2
3 "	0.8	99.2	0.2	99.9	1.2	1.6	1.8
4 "	0.6	99.4	0.1	99.9	1.2	1.4	1.8
5 "	0.2	99.0	0.2	99.8	0.7	1.6	1.5
6 "	0.6	0.1	0.1	99.9	1.5	1.2	2.4
7 "	0.8	0.0	0.8	0.2	1.4	1.2	2.0
8 "	0.2	99.6	0.4	0.2	1.2	1.5	2.9
9 "	1.8	0.0	0.6	0.8	1.6	1.6	2.6
10 "	W. 1.4	W. 1.4	W. 1.1	W. 1.2	W. 1.4	W. 1.8	W. 3.3
11 "	....	....	....	....	....	....	....
12 M.	1.1	1.1	0.7	0.3	1.0	1.5	3.7
1 P. M.	1.3	1.2	0.8	1.1	1.6	1.4	3.8
2 "	1.5	1.0	*1.1	1.1	1.6	1.6	3.8
3 "	1.7	1.2	1.2	1.3	1.9	1.6	3.7
4 "	2.1	1.2	1.3	1.2	1.9	2.0	3.6
5 "	2.1	1.6	1.2	1.7	1.8	2.0	3.6
6 "	2.8	2.0	1.7	1.8	2.2	2.2	3.8
7 "	2.1	1.7	1.8	1.6	1.9	2.2	3.8
8 "	3.1	1.4	0.9	1.0	2.0	2.2	3.8
9 "	1.7	0.9	1.4	0.5	2.4	2.3	4.6
10 "	1.2	0.6	1.4	0.5	1.7	2.2	4.6
11 "	0.2	0.7	0.8	0.0	1.8	1.9	4.2
12 Midnight	....	....	....	....	....	....	....
May 13—							
1 A. M.	0.6	0.6	0.7	99.2	0.7	1.8	3.4
2 "	....	....	....	....	....	....	....
3 "	1.0	99.4	0.6	0.0	1.0	1.7	2.8

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1901.							
May 18—							
4 A. M.	99.8	98.2	0.4	98.6	0.7	1.8	2.6
5 "	0.2	99.2	0.3	98.8	0.8	1.6	1.9
6 "	0.8	98.8	0.2	99.4	0.6	1.5	0.6
7 "	1.2	99.8	99.5	99.5	1.6	1.6	0.8
8 "	....	....	....	....	....	....	....
May 24—							
8 P. M.	2.2	1.2	1.2	2.1	....	....	2.6
9 "	2.5	1.2	0.8	2.2	2.4	3.0	2.4
10 "	2.1	1.1	1.2	1.7	3.0	2.4	2.6
11 "	1.8	0.9	0.4	1.2	2.5	2.6	2.4
12 Midnight	1.5	0.7	0.7	1.8	2.5	2.2	2.0
May 25—							
1 A. M.	1.0	0.6	0.4	0.8	2.2	2.2	2.0
2 "	0.4	....	....	....	....	....	1.8
3 "	....	99.0	0.2	99.8	1.7	1.7	1.7
4 "	0.5	99.9	0.6	0.0	1.8	1.2	....
5 "	0.0	0.1	99.9	0.6	1.4	0.9	1.8
6 "	0.5	99.6	99.8	0.8	1.5	1.2	1.0
7 "	0.2	99.7	0.5	0.3	1.4	1.0	0.6
8 "	0.9	0.6	0.9	0.5	1.6	1.5	0.4
9 "	1.0	0.8	1.1	1.3	1.7	1.4	0.9
10 "	2.0	1.0	1.5	1.2	1.7	1.7	1.5
11 "	1.4	1.2	1.5	1.6	2.1	1.5	1.0
12 M.	1.0	1.1	1.3	1.8	1.9	1.4	1.2
1 P. M.	1.7	0.7	1.2	0.8	1.1	1.5	1.8
2 "	1.2	0.8	0.6	1.2	1.7	1.8	1.8
3 "	2.1	1.0	1.1	1.8	1.5	1.7	2.4
4 "	2.0	0.9	0.0	1.5	1.8	1.7	2.7
5 "	1.2	1.4	1.8	1.7	1.8	1.8	3.1
6 "	1.8	1.6	0.9	1.8	1.7	1.8	3.1
7 "	2.0	1.8	1.8	1.7	2.0	1.8	4.8
8 "	1.4	1.4	1.8	1.2	2.0	2.1	4.8
9 "	1.4	1.8	0.9	1.3	1.7	1.8	4.4
10 "	....	....	....	....	....	....	....
11 "	1.8	0.0	0.6	99.9	1.6	1.5	4.1
12 Midnight	....	....	....	....	....	....	....
May 26—							
1 A. M.	1.0	0.8	0.6	0.2	1.6	1.5	4.5
2 "	....	....	....	....	....	....	....
3 "	0.6	0.0	0.8	99.7	1.4	1.1	4.8
4 "	0.8	0.3	0.8	0.7	1.6	1.2	3.5
5 "	99.7	0.4	0.9	0.1	1.4	1.0	3.0
6 "	1.7	0.5	0.0	0.2	1.2	1.4	2.2

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1901.							
May 26—							
7 A. M.	1.8	0.0	0.5	0.8	1.5	1.4	2.5
8 "	2.0	0.5	0.6	0.3	1.4	1.8	2.1
9 "	2.0	0.8	1.1	1.1	1.5	1.7	1.5
10 "	2.8	0.8	1.1	1.5	1.5	1.7	2.4
11 "	2.0	0.3	0.4	2.0	2.0	2.0	2.0
12 M.	2.1	0.8	1.6	1.8	1.2	2.0	1.7
1 P. M.	2.0	0.8	0.3	1.1	1.7	1.6	1.8
2 "	1.8	0.8	0.8	1.6	1.6	1.6	2.9
3 "	W. 98.3	W. 0.1	W. 0.3	W. 98.3	2.0	2.1	W. 0.1
4 "	97.4	0.5	0.1	97.3	2.0	2.0	0.5
5 "	98.2	0.1	0.2	97.7	1.7	2.6	1.4
6 "	99.9	99.9	1.1	99.2	2.1	2.5	2.2
7 "	0.1	0.8	0.8	99.8	2.4	2.4	2.9
8 "	99.7	0.0	1.0	0.1	2.4	2.1	3.8
9 "	99.9	0.1	1.1	0.2	2.3	2.4	3.6
10 "	0.3	0.0	0.7	0.2	2.5	2.4	3.5
11 "	....	....	....	....	....	....	....
12 Midnight	0.3	98.4	0.0	99.7	2.0	1.9	3.6
May 27—							
1 A. M.	0.1	99.9	99.8	99.9	2.0	1.9	3.5
2 "	1.7	0.1	0.1	99.7	1.7	1.8	3.5
3 "	1.2	0.6	0.5	0.3	1.9	1.9	3.2
4 "	....	....	....	....	....	....	....
5 "	1.5	0.1	99.8	0.2	1.9	1.4	2.7
6 "	1.6	0.0	0.4	99.9	1.0	1.6	1.5
7 "	0.9	0.2	99.9	0.6	1.2	1.7	1.8
8 "	....	....	....	....	....	....	....
May 31—							
4 P. M.	0.6	1.6	1.2	0.6	2.4	2.0	3.6
5 "	1.1	1.9	1.2	1.4	2.6	2.1	4.1
6 "	0.8	1.7	1.2	1.2	2.3	2.6	3.7
7 "	1.6	1.6	1.6	1.4	2.8	2.4	2.9
8 "	0.8	0.6	1.1	1.4	2.6	2.4	2.6
9 "	0.7	0.0	0.4	0.4	2.5	2.8	2.7
10 "	0.9	0.6	0.8	0.0	2.4	2.5	2.9
11 "	0.6	0.5	0.6	99.2	2.2	2.0	3.7
12 Midnight	0.2	0.2	1.0	99.4	2.3	2.8	3.5
June 1—							
1 A. M.	0.4	99.8	1.0	99.1	1.9	2.5	3.4
2 "	....	....	....	....	....	....	....
3 "	0.2	99.0	0.4	99.2	0.6	1.0	3.4
4 "	0.2	0.2	0.4	99.4	1.8	1.6	2.7
5 "	0.2	99.6	0.9	99.0	1.5	1.5	[illegible]

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1901.							
June 1—							
6 A. M.	99.8	99.7	0.0	99.2	2.2	1.8	2.1
7 "	0.1	99.3	0.1	99.6	1.8	1.4	2.0
8 "	0.8	99.7	0.3	0.3	1.8	1.4	1.5
9 "	0.8	0.5	0.4	0.9	2.0	1.7	2.3
10 "	1.0	0.8	0.9	1.0	1.8	1.8	2.5
11 "	1.8	1.0	0.6	1.2	1.8	1.7	3.2
12 M.	1.2	1.2	0.8	1.2	2.2	1.5	3.8
1 P. M.	0.9	0.4	0.4	1.2	1.8	1.6	4.2
2 "	1.2	1.0	0.9	1.6	1.6	1.8	4.7
3 "	W. 1.9	W. 2.1	W. 1.6	W. 2.1	2.0	1.9	W. 4.5
4 "	2.5	1.8	1.5	1.9	2.4	1.8	4.0
5 "	1.8	1.7	1.2	1.6	2 4	2.8	3.9
6 "	1.9	1.8	1.7	1.5	2.5	2.4	3.3
7 "	1.8	1.8	1.4	1.3	3.0	2.2	2.8
8 "	0.6	1.2	1.4	0.5	2.8	2.6	2.3
9 "	0.8	1.1	1.3	0.4	2.6	2.3	2.3
10 "	......	......	......	......	......	......	......
11 "	0.6	0.6	1.0	0.4	2.0	0.1	2.6
12 Midnight	......	......	......	......	......	......	......
June 2—							
1 A. M.	99.7	0.1	0.5	99.7	2.8	1.8	2.7
2 "	99.7	0.2	0.2	0.3	2.3	1.8	2.9
3 "	0.5	99.7	0.7	99.7	2.5	1.8	2.5
4 "	0.4	0.0	0.2	99.8	1.8	1.5	2.7
5 "	0.6	0.0	99.7	99.9	1.7	1.6	3.0
6 "	0.0	99.5	99.6	0.2	1.4	1.2	3.2
7 "	98.8	0.1	0.0	0.8	1.5	1.7	2.6
8 "	0.6	0.8	1.0	0.8	1.8	1.7	2.8
9 "	0.6	1.2	1.1	1.3	1.6	1.7	3.0
10 "	1.0	1.0	0.7	1.2	2.0	1.6	3.5
11 "	0.7	0.4	0.8	1.4	1.6	1.7	3.7
12 M.	1.3	0.6	0.7	0.4	1.8	1.7	4.2
1 P. M.	1.6	1.1	0.8	1.5	1.6	1.8	4.6
2 "	0.9	0.9	0.7	1.0	1.8	1.8	4.8
3 "	1.5	1.1	0.5	1.1	1.9	1.9	4.5
4 "	1.4	99.6	1.0	1.2	2.1	2.2	3.6
5 "	1.2	1.2	0.6	1.2	2.0	2.2	3.8
6 "	1.2	1.2	0.8	1.2	2.1	2.2	3.4
7 "	1.1	1.1	1.8	1.6	2.6	2.9	2.6
8 "	0.6	0.5	1.1	0.6	2.8	2.8	2.5
9 "	1.0	0.2	1.0	99.8	2.4	2.8	2.4
10 "	0.0	0.4	0.5	99.2	2.5	2.4	2.1
11 "	0.0	1.0	99.5	99.7	2.2	2.2	2.0
12 Midnight	......	......	......	......	......	......	......

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1901.							
June 6—							
1 A. M.	....	....	....	....	....	....	....
2 "	0.5	0.8	0.4	99.4	1.9	2.0	2.4
3 "	....	....	....	....	....	....	....
4 "	0.0	0.1	0.1	99.1	1.4	1.7	2.5
5 "	1.7	0.0	0.0	99.7	1.2	1.1	3.6
6 "	0.5	0.8	1.0	99.6	1.3	1.2	3.0
7 "	99.8	0.2	0.5	99.7	1.1	1.4	3.4
8 "	....	....	....	....	....	....	....
June 7—							
4 P. M.	1.4	1.6	1.5	99.7	1.5	1.9	3.0
5 "	0.5	0.8	1.4	0.2	1.9	1.8	2.6
6 "	0.9	0.9	1.2	0.8	1.9	1.5	2.1
7 "	0.9	0.6	0.6	0.6	1.9	2.0	2.4
8 "	1.3	0.4	1.2	0.4	2.7	2.0	2.8
9 "	0.9	0.8	1.0	0.4	2.0	2.0	3.5
10 "	....	....	....	....	....	....	....
11 "	1.0	0.3	0.8	0.7	2.1	2.3	3.6
12 Midnight	....	....	....	....	....	....	....
June 8—							
1 A. M.	1.8	0.6	1.0	0.8	2.0	1.6	3.2
2 "	....	....	....	....	....	....	....
3 "	0.0	0.0	1.0	99.7	1.4	1.7	2.9
4 "	1.0	0.4	1.1	99.8	1.6	1.7	2.7
5 "	1.0	0.2	0.8	99.7	1.8	1.5	2.6
6 "	0.8	0.2	0.8	0.8	1.6	1.6	2.2
7 "	1.8	0.8	0.8	1.1	1.4	1.6	2.4
8 "	0.4	0.6	1.0	1.0	1.9	2.0	2.1
9 "	0.6	0.8	1.2	1.1	1.8	1.6	2.4
10 "	1.6	1.3	1.3	1.1	2.2	2.2	2.6
11 "	1.6	1.9	1.1	0.7	2.1	2.2	3.8
12 M.	1.3	1.2	1.1	1.1	1.9	2.1	3.8
1 P. M.	1.9	0.9	1.0	0.7	1.9	2.1	4.1
2 "	1.4	1.0	0.6	0.9	1.8	2.1	4.5
3 "	2.3	0.1	0.4	0.6	1.9	2.1	4.6
4 "	3.1	1.1	1.1	1.2	1.9	1.9	4.8
5 "	3.0	1.2	0.8	1.4	2.3	2.3	5.0
6 "	2.6	1.8	1.2	1.6	2.0	2.3	5.0
7 "	3.1	1.3	1.6	1.9	2.4	2.3	4.9
8 "	W. 2.0	W. 0.6	W. 1.8	W. 1.4	2.6	2.2	W. 3.9
9 "	1.5	1.0	1.0	0.7	2.2	2.2	4.0
10 "	....	....	....	....	....	....	....
11 "	....	....	....	....	....	....	....
12 Midnight	....	....	....	....	....	....	....

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No. 18.
1911.							
June 9—							
1 A. M.	1.9	99.2	0.2	99.8	1.8	1.5	3.6
2 "	1.4	0.0	1.0	99.3	2.1	1.8	3.4
3 "	1.2	0.4	0.7	99.6	1.6	1.3	2.7
4 "	0.1	99.8	0.7	99.2	1.2	1.4	2.9
5 "	1.0	99.2	99.3	99.2	0.8	1.0	2.6
6 "	1.8	99.8	99.6	98.6	1.0	0.9	2.7
7 "	0.6	0.2	0.1	0.1	1.8	0.6	2.6
8 "	0.2	0.2	0.3	0.2	1.8	1.3	2.6
9 "	1.6	1.5	1.1	0.8	1.6	1.8	2.9
10 "	1.0	0.7	0.9	0.7	1.7	1.1	3.8
11 "	1.7	0.8	0.6	0.8	1.8	1.0	4.1
12 M.	1.6	0.5	0.9	1.2	1.4	1.5	4.3
1 P. M.	1.6	0.6	0.7	0.8	1.4	1.6	4.8
2 "	1.9	0.4	0.8	1.4	1.4	1.7	4.6
3 "	W. 2.6	W. 1.2	W. 1.6	W. 2.6	1.2	1.7	W. 4.5
4 "	2.8	1.0	0.7	1.0	1.8	2.1	4.6
5 "	2.8	0.3	0.9	1.3	1.9	1.8	4.8
6 "	2.6	1.4	1.6	1.9	2.3	2.4	3.6
7 "	2.8	1.4	1.6	1.7	2.2	2.8	3.9
8 "	2.8	0.8	1.1	1.4	2.6	2.4	3.7
9 "	2.2	0.8	1.2	1.8	2.1	2.0	3.6
10 "	2.0	0.6	1.7	1.0	1.8	1.7	3.7
11 "	....	....	....	....	....	....	....
12 Midnight	....	....	....	....	....	....	....
June 10—							
1 A. M.	1.9	0.8	0.7	0.2	1.2	0.9	3.2
2 "	1.5	0.0	0.2	0.8	0.9	1.1	2.8
3 "	1.6	99.6	0.5	9.5	1.0	1.4	2.6
4 "	....	....	....	....	....	....	....
5 "	0.7	99.0	0.6	0.4	0.9	1.2	1.8
6 "	99.4	99.0	0.8	0.2	0.9	0.9	1.9
7 "	1.2	0.2	0.6	0.6	1.8	1.4	2.7
8 "	0.7	0.4	99.7	0.8	1.8	1.8	2.6
9 "	0.6	1.0	0.8	0.8	1.5	1.8	2.7
10 "	1.7	0.7	0.6	1.0	1.6	1.4	3.0
11 "	1.4	0.6	1.1	1.2	1.6	1.4	3.6
12 M.	1.8	0.8	0.8	0.8	1.9	1.6	3.8
1 P. M.	2.5	0.7	1.8	0.8	1.4	1.7	4.4
2 "	2.6	0.6	0.2	1.1	1.8	1.9	4.6
3 "	3.3	1.1	1.8	0.6	1.4	1.6	4.7
4 "	W. 3.9	W. 2.1	W. 1.9	W. 2.9	1.4	2.1	W. 5.0
5 "	3.6	1.6	1.6	1.6	2.1	2.5	5.0
6 "	3.7	1.8	1.8	2.5	2.6	2.4	4.8

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 95.	Calf of 14.	No 18.
1901.							
June 10—							
7 P. M.	3.8	2.2	1.6	2.2	2.2	2.6	4.6
8 "	3.4	1.6	1.2	1.7	2.6	2.6	4.7
9 "	2.5	99.8	0.8	1.2	2.8	2.4	4.6
10 "	1.8	1.5	1.3	1.1	2.5	2.4	3.9
11 "	2.1	1.0	1.0	1.5	3.0	2.4	3.8
12 Midnight	....	....	....	....	....	....	....
June 11—							
1 A. M.	2.7	0.6	0.3	0.8	1.4	2.0	3.2
2 "	2.3	1.2	99.9	0.4	1.5	2.0	3.4
3 "	....	....	....	....	....	....	....
4 "	2.0	0.6	0.6	99.6	1.6	2.0	3.2
5 "	0.8	0.6	1.0	99.8	1.0	1.7	3.2
6 "	0.4	1.0	0.7	0.6	1.6	1.5	3.0
7 "	0.6	1.0	0.7	0.8	1.2	1.6	2.1
8 "	1.3	0.7	0.7	0.7	1.5	1.6	2.8
Minims inje'd at 5 P. M.	65	90	55	70	16	20	30
June 15—							
9 A. M.	3.0	1.6	1.5	2.1	2.2	2.2	3.1
10 "	3.6	1.6	1.3	1.9	2.1	2.5	3.5
11 "	3.1	99.8	0.8	0.3	2.0	2.0	3.8
12 M.	1.7	0.5	0.5	99.7	1.1	2.0	3.5
1 P. M.	1.9	1.0	1.0	98.4	1.2	1.7	3.4
2 "	o. 0.1	o. 0.0	o. 99.1	o. 0.2	o. 0.7	o. 1.8	o. 1.7
3 "	o. 0.2	o. 0.4	o. 1.0	o. 99.6	o. 1.0	o. 1.4	o. 0.0
4 "	n. 1.2 o. 0.6	n. 99.4	n. 99.4	n. 98.8 o. 97.4	n 1.4 o. 0.4	n. 1.8 o. 0.2	n. 3.0 o. 1.2
5 " (Inj.)	n. 1.5	n. 0.6	n. 0.8	n. 0.2	n. 2.0	n. 1.6	n. 3.1
6 "	1.9	1.2	1.0	0.6	1.7	2.0	3.7
7 "	2.6	1.4	0.4	0.0	2.4	2.1	3.4
8 "	2.4	1.2	1.1	0.9	2.4	2.1	4.2
9 "	3.3	0.0	1.7	99.7	2.5	2.1	4.0
10 "	3.6	0.4	0.5	0.0	1.8	2.0	4.2
11 "	....	....	....	....	....	....	....
12 Midnight	3.5	0.6	0.6	99.7	1.8	2.2	4.0
June 16—							
1 A. M.	....	....	....	....	....	....	....
2 "	2.4	0.2	1.6	99.4	1.9	2.2	3.6
3 "	2.4	0.6	1.2	0.2	1.9	2.0	4.0
4 "	2.0	0.0	0.0	0.2	1.5	1.8	3.8
5 "	2.0	99.0	0.2	98.8	1.2	1.6	3.6
6 "	2.8	99.4	0.3	99.6	1.8	1.7	3.4
7 "	1.7	99.8	0.3	0.0	1.8	1.6	3.4
8 "	2.4	1.0	0.5	0.8	1.6	1.6	3.4

TABLE V.—Continued.

Temperatures of Tuberculous Cows and Their Offspring.

DATE.	No. 59.	No. 72.	No. 15.	No. 14.	Calf of 96.	Calf of 14.	No. 18.
1901.							
June 16—							
9 A. M.	2.5	1.0	0.6	0.6	2.0	2.1	3.3
10 "	2.9	1.0	1.0	1.2	1.8	1.9	3.6
11 "	2.7	1.3	0.9	1.5	1.8	1.8	3.6
12 M.	3.0	1.6	1.1	1.5	1.7	1.8	4.0
1 P. M.	3.5	1.4	1.2	1.5	1.6	1.8	4.3
2 "	W. 3.0	W. 1.5	W. 2.2	W. 2.8	1.8	1.6	W. 3.8
3 "	2.4	1.6	1.2	0.6	2.0	1.9	3.8
4 "	2.8	1.3	1.1	0.7	2.0	1.8	4.1
5 "	2.6	0.7	0.8	1.1	1.9	1.9	3.8
6 "	2.3	1.0	1.1	1.2	1.9	1.7	3.7
7 "	2.4	1.2	1.1	1.5	2.4	2.5	3.4
8 "	2.7	1.0	(?) 1.7	1.6	2.8	2.0	3.4
9 "	2.4	0.6	1.4	0.8	1.6	1.8	3.4
10 "	....	....	....	....	....	....	....
11 "	....	....	....	....	....	....	....
12 Midnight	1.1	99.1	1.0	0.2	1.5	2.0	2.9
June 17—							
1 A. M.	1.9	1.4	1.4	0.2	1.4	1.2	2.4
2 "	....	....	....	....	....	....	....
3 "	1.2	1.9	1.5	0.0	0.4	1.1	2.5
4 "	1.2	0.0	1.0	99.2	0.4	1.0	2.4
5 "	0.9	0.1	1.0	98.7	0.5	0.6	2.2
6 "	1.5	0.1	0.6	99.4	0.4	0.6	2.1
7 "	1.8	99.5	99.8	99.8	0.7	0.4	2.1
8 "	1.3	0.4	0.8	0.0	0.8	0.8	2.5
9 "	2.1	1.5	0.9	1.7	1.4	1.2	3.2
10 "	2.1	1.2	1.1	2.1	1.4	1.6	3.2
11 "	2.2	1.3	1.2	1.4	1.4	2.0	3.8
12 M.	2.4	1.5	2.5	1.4	1.3	1.6	5.0
1 P. M.	2.6	2.8	3.4	2.2	1.4	1.6	5.0
2 "	3.2	2.2	4.2	2.1	1.2	1.7	4.7
3 "	3.5	3.1	4.2	2.4	1.4	2.0	5.0
4 "	4.0	2.8	3.0	2.2	1.7	2.2	5.2

REPORT OF BOTANIST.

REPORT OF THE BOTANIST.

For the year ending November 30th, 1901, the work in the Botanical Department has been largely upon the two acres of the Experiment Area at the College Farm, supplemented with studies in the Laboratory and field work in various parts of the State.

As for the past eight years the experiments in the field have been largely devoted to truck crops, with less attention to tests of fungicides and more to the breeding of varieties of corn, beans, eggplants, tomatoes, cucumbers, squashes, etc.

Starting with a white and a black variety of sweet corn in 1899, a combination of the two has resulted in a few instances, the present season, in ears that were entirely with red grains. At the same time interesting points in plant-breeding have been obtained.

The crossing of a yellow variety of tomato with a red one has resulted in producing plants of remarkable vigor and a blending of qualities that may be of much profit. One of the results is a number of plants that are remarkable for healthy vine and fruits that are *nearly seedless*.

The work of combining two varieties of dwarf lima beans has resulted in an improved sort that is very promising. In this connection there have been reversions to the pole type that with these new crosses may prove advantageous.

The most immediate results in the crossing have been with the eggplants, and a new form has developed that may surpass all others in the desirable qualities in this vegetable fruit. All the crosses show a vigor and productiveness of plant that is very gratifying.

In cucumbers the progress in breeding for a spineless fruit has progressed ; many types are reached but none are fixed.

Squash crosses are showing some features of interest.

The testing of salad plants has been continued and the Swiss Chard and New Zealand spinach have shown much to recommend them for general use.

The hybrid salsify has bloomed and fruited this season and a good stand of plants for testing the quality of the roots next year is now upon the ground.

Observations upon the asparagus rust have been continued and

additional facts determined with regard to its spread through the United States and its dependence upon the prevailing characteristics of the weather.

As usual the work with weeds has been the identification of foul stuff in commercial seeds and the observations upon the weed plot, which has been maintained for several years in a wild. condition. The finding of broom rape upon clover and another species upon tomato are some of the weed events of the year.

A new greenhouse, 24 by 80 feet, was used for the first time last winter, and in it some results were obtained in germination, particularly as to albinism in corn, the dimorphism in buckwheat and the checking of mildews with various fungicides.

Some studies were made of the dodders, which as parasitic plants are often serious pests to clover, flax and otber field crops.

One bulletin has been issued from this department since the last annual report was published; namely, June 1st, 1901, Bulletin 151, "Bean Diseases and Their Remedies," with four page plates, nine figures and twenty-eight pages.

The Station Herbarium has grown with the usual annual accessions from various sources.

In its many details the work at the Experiment Area and in the greenhouse has been, as formerly, in charge of Mr. J. A. Kelsey, and any success in results in crossing and spraying is largely due to his faithfulness.

The Experiment Area.

In the accompanying plan, Figure 1 shows the method of plotting the two acres known as the Experiment Area; it also locates in the plots the various crops that have occupied the ground the present season.

The seven series from 0 to VI. run up and down a slight incline of the field and are separated by four-foot paths, while the four plots, 33 by 66 feet, in each series extend right and left of the plotted page.*

To improve the soil, naturally a gravelly clay underlaid with yellow gravel, stable manure at the rate of twenty tons per acre has been added each spring during the past seven years. Last autumn nearly all the plots were sown to rye after the regular crop was removed. This made a good live cover that helped to hold the surface soil from washing in winter, but grew too rapidly in the spring, so that barley is used instead this season.

* The plotting is given in full detail in the report for 1894, p. 279.

The Experiment Area.

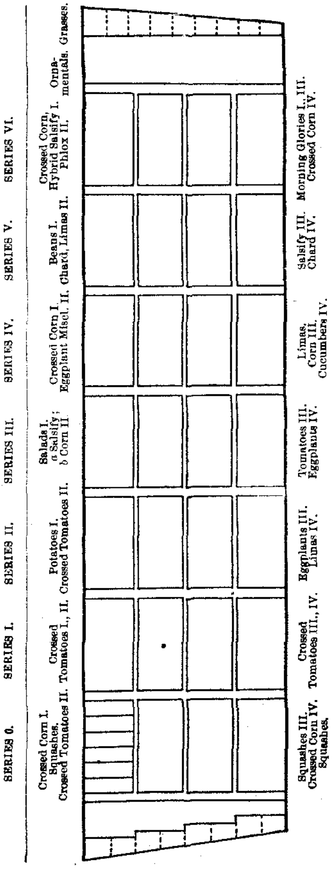


Fig. 1. The Experiment Area in 1911.

EXPERIMENTS WITH TURNIPS—Concluded.

Series I., that had been in turnips for seven years, was set this year to crossed tomatoes. First, because the demonstration was made that lime is a satisfactory remedy for the club-root; secondly, turnips do not thrive as a continuous crop for many years, and thirdly, owing to the limited space, the land was needed for other experiments.

The reader who is interested in the club-root experiments, which were the chief reason for holding turnips for seven years and twelve consecutive crops upon the same land, will find the tabulations and conclusions upon pages 410–413 of the report of this department for last year.

POTATO EXPERIMENTS IN 1901.

Only Plot I., Series II., was in potatoes the present season, and this for the seventh consecutive year. The continuous cropping with potatoes is not advisable and was only indulged in for the sake of the experiments witb soil fungicides for the scab. The results have not been uniform in these experiments, and while sulphur gave much promise the tests need to be many upon various kinds of soils before final judgment is rendered in the case. Owing to the demands of other lines of field experiments, mainly with plant breeding, the tests with potatoes must for a time be considerably curtailed.

Last season it was found that a shavings mulch gave a gain over the adjoining uncovered land of nearly as 5 to 3. With this in mind and the fact that the mulch seemed to protect the potatoes from scab, it was concluded to continue Plot I., Series II., in potatoes, although for the seventh crop, wbich would very surely be a small one. The early part of the season was unfavorable for potatoes and the crop throughout the State is only a fraction of the average.

The upper third of the plot was mulched with shavings that are purchased in bales of 100 pounds each and used for stable bedding. Fresh sbavings to the depth of two inches were applied in July, and thereafter no cultivation was given to this portion of the plot.

The harvest was upon October 8th, and the following table shows the results in number of marketable potatoes, weight of the same and number of hills:

		Belt 1.	Belt 2.	Belt 3.	Belt 4.	Belt 5.	Belt 6.
Potatoes	Mulch	24	28	40	40	27	21
	No Mulch	76	36	78	45	47	28
Weight	Mulch	6¾	5½	11¼	10¾	7	4
	No Mulch	17½	6½	17¾	11¼	9¼	5½
No. of hills	Mulch	14	18	19	19	19	18
	No Mulch	34	35	36	34	37	32

Total potatoes upon mulched ground 180, and upon the unmulched area 310. By bringing the two portions to the same size the relative numbers are: for the mulched soil 360 and the unmulched 310. The relative weights became for mulched land 91 pounds and 67¾ for the unmulched ground, a difference of nearly a half in favor of the mulched area.

The following table is of the amounts of scab, estimated as in former years, in terms of per cent.:

	Belt 1.	Belt 2.	Belt 3.	Belt 4.	Belt 5.	Belt 6.	Average.
Mulched	65	40	70	45	45	5	45
Unmulched	50	50	75	70	60	60	61

It is seen that the mulched land shows less scab, which may be due to the potatoes forming nearer the surface of the soil, sometimes even in the mulch, where there may be fewer scab germs.

EXPERIMENTS WITH BEANS.

Plot L, Series V., has been continuously in bush beans since the Experiment Area was started in 1894, with two crops for each season, excepting for the present year. Only two sorts, namely, "Green Flageolet" and "Saddleback Wax," were grown, they being planted in alternate rows upon May 16th. On account of the cold, wet weather, shortly after planting, the stand was not good with the first-named sort and the rows of the other were somewhat broken.

Upon July 30th it was recorded that there was much bacterial blight upon the "Green Flageolet." This is among the most susceptible of all the bush beans to this disease, but the alternate rows of the "Saddleback Wax" were not exempt. This last-named variety is but little inclined to the blight, and this selection of the extremes in susceptibility was purposely made in order to study this obscure point.

Microscopic examinations were made of the leaves and other parts of the two varieties, but enough evidence is not yet found to warrant any conclusion as to the exact reason for the great susceptibility in the one case and comparative immunity in the other.

The hope of a natural cross between the two sorts, by growing them side by side, was not realized, and the demonstration is made that, with plants like beans, where close fertilization is easy, and possibly the rule, one must resort to castration and the other accompanying details of hand pollination to secure a cross. Beans, peas and plants

of that class are very different from corn, which crosses so readily that difficulty lies in keeping a variety pure when grown anywhere near another variety.

In another part of the Experiment Area, where the suspected crosses between the two above-named varieties of beans of last year were grown this season, there was considerable of the bean-pod spot (*Colletotrichum lagenarium* Pass.) upon the "Saddleback Wax." This is interesting as showing that this disease may appear upon a piece of land after it has been almost entirely absent for some years.

There was no record made of the yield of the two varieties, the comparative productiveness having been fully determined in previous years. The crop was such, however, as to confirm the opinion expressed before, that, under good culture and a fair degree of manuring, bush beans may be grown upon the same soil for at least eight years, with two crops in each season.

EXPERIMENTS IN CROSSING LIMA BEANS.

Last year twenty plants were secured as crosses between the "Henderson" and "Burpee" types of dwarf limas. The seeds upon all this score of plants were planted this year and the results are here recorded.

In a general way, it may be said that the vigor of the plants was satisfactory. There were many individual differences from the time the seedlings unfolded their first true leaves, and the plot showed those evidences of a mingled blood that plant-breeders find so difficult to set down in words. Some rows, that is, plants from one parent, were more uniform than others, favoring the "Henderson" or the "Burpee" as it might be. As they increased in age all of the hundreds remained true to the dwarf type excepting seven plants, and those were given poles and climbed, with one exception, with the vigor characteristic of genuine pole beans. It remains to be determined what the progeny may desire to do. In passing, it may be said that the future of these climbers is full of interest, for they represent a combination of qualities that may be of commercial importance. These plants are treated separately elsewhere.

In fruitage there is a remarkable constancy for all the twenty sets of plants adhere when quite closely to a type of pod and seed that make it easy to distinguish them from either of the crosses. It is not necessary to repeat in full the statement made in the report of last year, where a full page plate was employed to exhibit the cross

in comparison with the pods of the two parents placed along side. The engraving here introduced will serve to show the characters of the seeds as shown in a small quantity of each.

Opportunity has come this season to test the quality of the cross, and it compares favorably with that of the "Burpee" and is far superior to that of the other parent. While not as large a seed as the "Burpee," it is large enough for a lima, and, when its yield is noted, the practical grower should be pleased with it.

The following is the result of the crossed plants for the year. Some parents produced only a few seeds last season and those from two out of the twenty failed to produce plants this season :

Parent.	No. of Plants.	No. of Ripe Pods.	No. Green, Filled.	No. Green, Empty.	Total.
1	Failed	....	....	....	....
2	2	2	35	3	40
3	3	13	37	....	50
4	1	5	11	....	16
5	19	425	46	5	476
6	20	592	65	18	675
7	70	1,200	325	40	1,565
8	1	9	17	....	26
9	72	1,227	338	95	1,660
10	32	775	85	40	910
11	33	570	55	21	646
12	5	193	44	....	237
13	29	705	305	25	1,035
14	28	940	165	15	1,120
15	46	995	131	10	1,136
16	Failed	....	....	....	....
17	21	332	25	10	357
18	69	1,597	312	80	1,989
19	16	560	210	30	800
20	5	96	35	10	141
Totals	472	10,236	2,241	408	12,879

The average number of pods to a plant is 27.

A corresponding plot of ground was devoted to alternate rows of the two parent varieties and these harvested the following :

	No. of *Plants.	Ripe Pods.	Green Pods.	Empty Pods.	Total.
Burpee	369	449	1,056	620	2,125
Henderson	700	3,550	340	350	4,240

It is seen that the "Henderson" produces about twice as many pods as the "Burpee" upon a given area, and this is due to the

fact that the plants are smaller and may be grown closer together. Another fact is the earliness of the "Henderson," for four-fifths of the pods were mature, while less than one-fourth were ripe in the lot of "Burpee" plants. The average was six pods to a plant.

With the crossed plants, while the yield was 27 pods per plant, the matured pods made up five-sixths of the crop and the empty pods one-thirty-second of them all. In short, while the productiveness is more than four times that of the parents, the earliness is ahead of the "Henderson."

The relative size of the beans is well shown in the engraving (Plate I.), and the cross is seen to be nearer the "Burpee" than the "Henderson." In quality the same is true, and, while not as "rich" as the "Burpee," it is nearer to it in this important quality than the "Henderson."

The following eight plants were pole beans :

Parent.	No. of Plants.	Ripe Pods.	Green Pods.	Green, Empty.	Total.
13......................	1	24	2	14	40
12......................	2	64	35	107	206
15......................	2	61	130	60	251
18......................	1	23	42	57	122
20......................	2	209	355	132	696
	8	381	564	370	1,315

The two from the parent plant No. 20 are remarkable in their very large yield, one of them giving 404 pods and the other 292. Both are valuable stock for further growth, as these and all the other six plants are, of course, not like the parents, and become the starting points for new lines of breeding possible for pole limas.

EXPERIMENTS IN CROSSING TOMATOES.

Tomatoes were given much attention and space in the Experiment Area. From the large number of lots of seed saved from crossed plants of the previous season the following were chosen from red-fruited plants: numbers 6, 7, 17, 25, 32, 33, 52, 62, 84, 92, 97, 104, 144, 150, 168, 176, 178, 182, and from yellow-fruited plants numbers 98, 112, 113, 122, 125 and 126. The performances of these parent plants are given in full upon pages 431 to 439 of the report for 1900.

The whole of Series I. was devoted to the seedlings of these crosses and Plots I., II. and III. received the above numbers 6 to 182 and

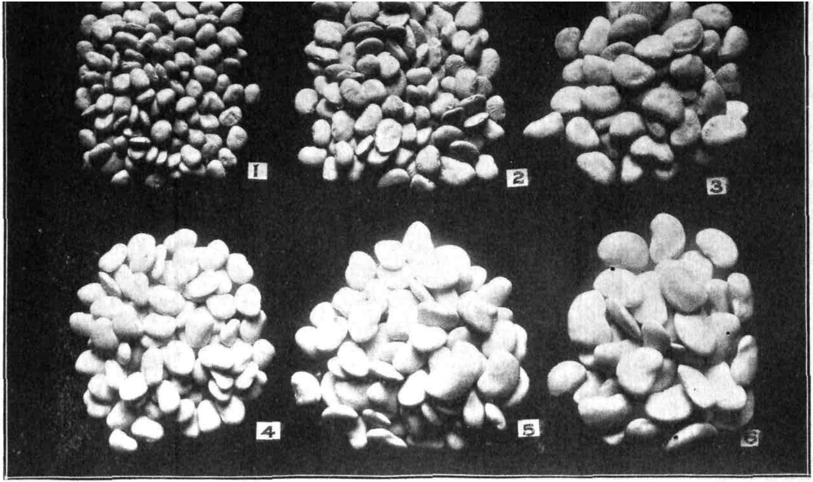


PLATE I.

Crossed Lima Beans Upper three dry seeds; lower three fresh seeds. Nos. 1 and 3 "Hendersin," Nos. 2 and 5 the Cross, Nos. 3 and 6 "Burpee" (size much reduced).

Plot IV. the six numbers 98 to 126. There were, therefore, three plots with plants from red fruits and one plot with plants from yellow fruits. Each parent number was assigned to a belt and was represented by ten plants.

The following table is made up from the results of each set of plants :

		Range of Fruitfulness.	Average Fruitfulness.		
Parent (Red) No.	6	48 to 120	84	Two	Yellow.
	7	57 " 125	98	"	"
	17	47 " 110	78	"	"
	25	45 " 128	84	No	"
	32	39 " 130	81	Two	"
	33	72 " 139	102	One	"
	52	50 " 102	79	No	"
	62	29 " 110	65	One	"
	84	17 " 125	79	No	"
	92	40 " 72	64	"	"
	97	42 " 133	73	"	"
Parent No.	104	51 to 131	90	No	Yellow.
	144	58 " 143	85	"	"
	150	51 " 188	108	One	"
	168	28 " 103	63	"	"
	176	66 " 99	78	No	"
	178	65 " 140	96	One	"
	182	48 " 179	103	"	"
Parent (Yellow) No.	98	43 " 92	61	Two	Red.
	112	31 " 105	60	No	"
	113	29 " 81	56	"	"
	122	40 " 66	54	"	"
	125	36 " 101	63	"	"
	126	22 " 139	75	"	"

Plot IV., bearing the yellows, is perhaps the least congenial soil for tomatoes, and this may account for the somewhat smaller average for the last six lots of plants. The following table shows grand averages for the four plots :

		Average.
Plot 1	64— 90	77
Plot 2	78—102	90
Plot 3	63—108	85 5
Plot 4	54— 75	64.5

The full record of each of the 240 plants, considered in brief above, is kept on file, in which the time when each fruit was picked is given and the earliness or lateness of the plant, along with its productiveness, are a matter for reference.

Plant No. 67 of the 1900 crop was from a seed of a red fruit resulting from a cross of "Golden Sunrise" upon the "Dwarf Champion," and with a record of 83 fruits, all of which were below average size, but nearly free from seeds. The plant was unusually large and vigorous, so that it was dubbed "Giant," while the foliage had a mottled appearance, as if the differing green of the two parents had not fully blended.

Thirty-seven seedlings from the fruits of this unusual plant were set in Plot II., Series II., and the following is the record of the yield for each :

	August.				September.				October.		Ripe.	Green.	Total.	Color.	Foliage, &c.
	10	17	24	31	7	14	21	28	5	25					
No. 1											0	0	0		Thin. (See Pl. II.)
" 2							2				2	0	2		Normal.
" 3				1			2	1	3	1	8	0	8	red.	Thin.
" 4											0	0	0		Potato-like. (Pl. II.)
" 5							1		1		2	2	4	red.	Fruit plum-shaped. (Pl. II., 2.)
" 6							1			1	2	7	9	red.	
" 7							7	3	2	4	16	25	41	yellow.	Rank growth. (Pl. II.)
" 8								1	3	9	15	17	30	red	
" 9								2	4	4	10	20	30	red.	
" 10									3		3	0	3	red.	
" 11		1								3	3	4	7	red.	
" 12											0	0	0		
" 13											0	0	0		Erect, bushy. (Pl. II.)
" 14			2		21	9	23	14	9	14	95	60	155	red.	
" 15											0	0	0		
" 16	1		1		4		11	5	6	4	32	0	32	red.	
" 17					1		11	10	5	8	35	0	35		
" 18		1		1	16	8	80	14	10	14	94	45	139	yellow.	
" 19			5	1	16	11	41	16	12	10	115	42	137	yellow.	
" 20		7	2	4	21	4	46	29	8	5	126	8	134	yellow.	
" 21							22				22	37	59	red.	
" 22		2		6	7	2	15	11	2	4	49	0	49	yellow.	
" 23					14						14	0	14	red.	
" 24			1	8	19	25	65	80	120	80	393	13	406	red.	"Dulcamara." (Pl. II., fruit 3.)
" 25				10		13	33	20	6	3	85	18	93	yellow.	
" 26												6	6		
" 27												4	4		
" 28				7	7	2	2	9	20	10	57	13	70	red.	
" 29				1	6	6	14	5	12	8	52	18	70	red.	
" 30			1			1	8	7	12	2	31	2	33	red.	
" 31				4	8	4	10	4	2	1	33	0	33	red.	
" 32			1	10	12	1	7	2	3	9	54	15	69	red.	
" 33			1		6	3	8		4	6	28	15	43	red.	
" 34					26	2	16	11	13	22	90	22	112	yellow.	
" 35			1		7	3	13	4	5	16	49	40	89	red.	
" 36			3	3	15	1	15	3	2	2	44	4	48	yellow.	
" 37			3	3	7		10	9	10	4	46	8	54	red.	

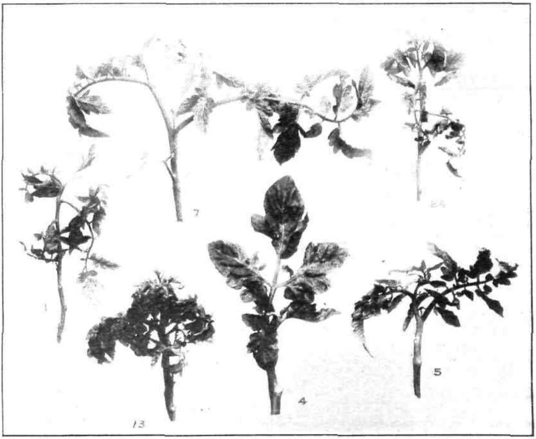


PLATE II.

Variations in Tomatoes—seedlings of No. 67. Stems and leaves No. 1, a fine nine-leaved, fruitless plant. No. 4, a potato-like fruitless plant. No. 5, an upright plant with plum-like fruit, nearly seedless. No. 7, a rank-growing plant. No. 13, erect-bushy fruitless plant. No 24, a fine-leaved spreading plant, with small cherry fruit.

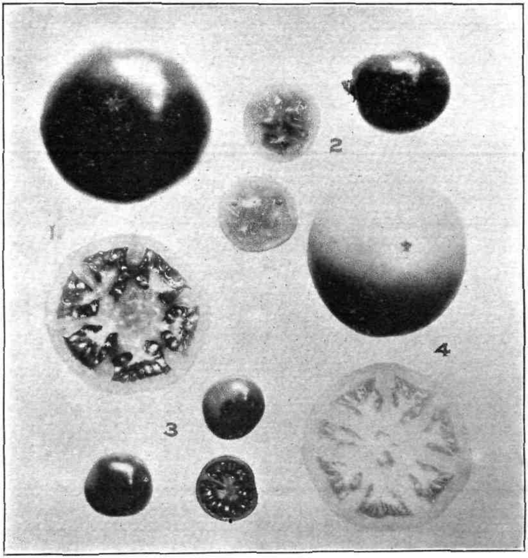


PLATE II.

Variations in Tomatoes—No. 1, an average red fruit, also in sectional view. No. 2, plum-shaped fruit, with nearly solid flesh. No. 3, the cherry tomato, with many seeds. No. 4, a type of the yellow fruits, and sectional view of same.

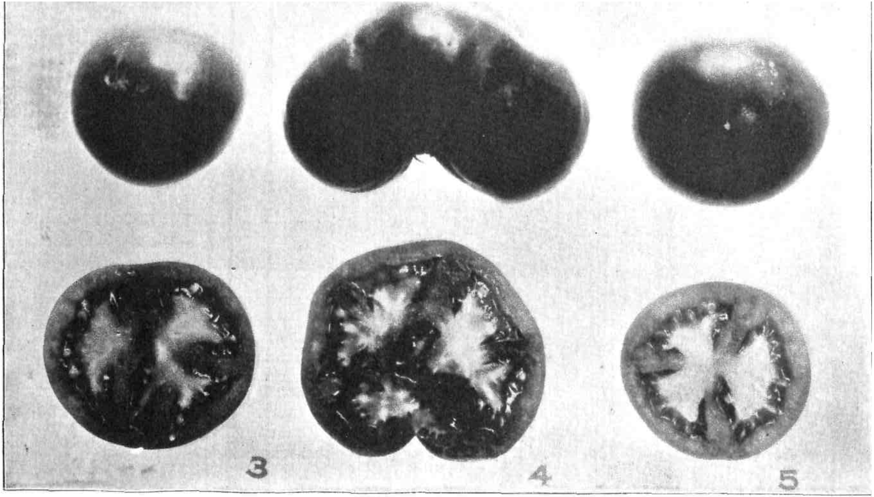


PLATE III.

Tomatoes from No. 177 of 1900 crop showing their nearly seedlessness as grown in the field (see Plate X. for those grown under glass).

It is seen that the number of fruits ranged from 0 to 406, ten were below ten and six were over a hundred. Some showed marked earliness and matured all their fruits, as Nos. 16 and 17, while others were late as Nos. 7, 18 and 35. Plate II. shows variations in the foliage and fruit of this lot of tomatoes.

Plant No. 177 of the 1900 crop was from a seed of a red fruit resulting from a cross of "Golden Sunrise" upon "Dwarf Champion," with a record of only 27 fruits, all small and with the seeds ranging from none to six to a fruit. This plant was remarkable for its great size, standing above the surrounding plants. The flowers were of unusually large size and added to the gigantic appearance of the plant.

Several of the seedlings from this plant were deformed and failed to reach much size, and only five specimens were set in the field, with the following results :

Lot 177.	Aug. 24.	Sept. 21.	Sept. 28.	Oct 5.	Oct. 25.	Total ripe.	Green.	Total.	Color.
Plant 1......	.....	1	2	1	8	12	4	16	red.
" 2......	.....	.....	2	2	1	5	1	6	red.
" 3......	1	3	.....	1	3	8	22	30	red.
" 4......	.....	2	1	1	9	13	12	25	red.
" 5......	.....	5	4	9	3	21	12	33	red.

These fruits were of fair size and many of them had but few seeds. The specimens photographed for Plate III. were from those that are interesting, because of their comparative seedlessness.

The plants all fruited late, there being only one fruit picked before September 21st, and the yield in all cases was small, ranging from 6 to 33 fruits. The fruits were all red and of fair size, with a small percentage of average seediness, and the plants were of the spreading "Sunrise" type, although not large.

Tomato Stock Plants.

One-half of Plot III., Series III., was kept in tomatoes for the eigbth successive time, two rows to each belt, the "Golden Sunrise" and "Dwarf Champion" alternating with five plants to a row. The fifteen plants of "Sunrise" in fruitfulness ranged from 55 to 147, with an average of 91, while the "Champions" ranged from 32 to 149, with an average of 61.

As in former years the "Snnrise" is seen to be much tbe more productive sort, but being yellow is inferior as a market fruit ; but

by those who have overcome the "color impression" the yellow is often preferred. The "Champion" comes into bearing earlier, and if green fruits were excluded from the record there would not be much in favor of the "Sunrise."

This crop shows that fair crops of tomatoes may be grown continuously upon the same land when the latter is kept in good tilth and the plants are sprayed, and all diseased fruits are promptly removed from the field.

EXPERIMENTS IN CROSSING CUCUMBERS.

From the crosses effected in 1899 between the "White Spine" upon the "White Pearl," twelve plants were grown last season. The characteristics of the fruit of this cross were shown in Plate II. of the report for 1900, along with those of the two parents. Seeds of the fruits of the above cross were used to fill Plot IV., Series IV., there being 36 hills.

Barring the severe attack of the beetles when the plants were small and saved from them only by timely vigilance, the use of insecticides, net covers and hand-picking combined, the plants made a fine growth and exhibited a vigor that was satisfactory. When the fruits appeared it was at once evident that the plot bore a motley lot of crossed plants. Many of them produced fruits of all degrees of color, from the clear white to a mottled, middle type and then on through all shades of green to the greenest that are produced. In size and shape the variation was no less, for some were nearly round, while others were long and slender. The type that was fairly uniform the previous year had been broken up in the second generation, quite in keeping with the general rule with crossed and hybrid plants.

In the midst of the season several of the more evident types of marketable size were selected for photographing, and Plate IV. shows the appearance of these in general form, but the shades of green are only unsatisfactorily shown.

One of the chief points in mind in this crossing was the removal of the spines, and this has been quite fully accomplished in some instances, while contrariwise other crossed plants produce fruits of remarkable roughness. For example, if one makes a comparison between Nos. 7 and 8 in the engraving (Plate IV.) with Nos. 14 and 15, he will be impressed with the spines upon the former and their nearly entire absence from the latter.

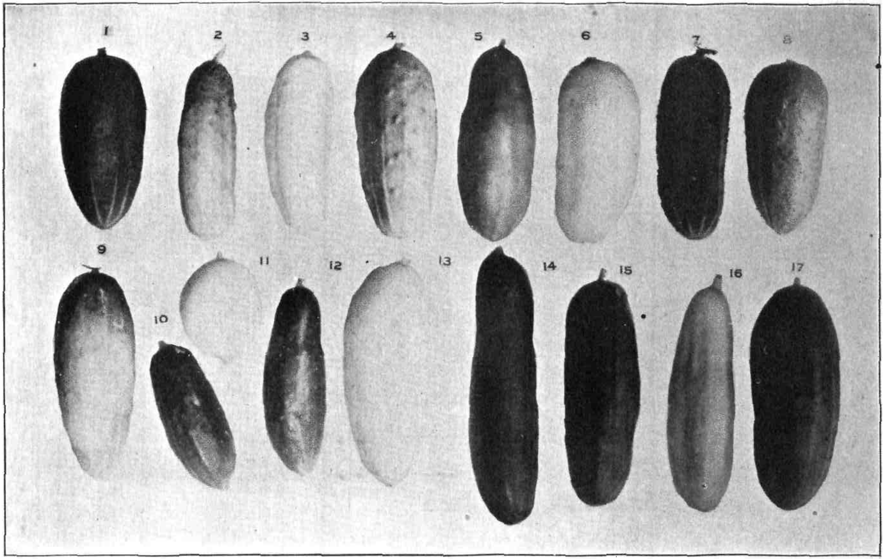


PLATE IV.

Crossed Cucumbers. Types of fruits varying from the round white (*No. 11*) to the long green (No. 14). Some are very spiney (Nos. 7 and 8), while others are smooth (Nos. 14 to 17).

Notes on Cucumbers.

The following are some of the notes made September 5th, upon the specimens shown in Plate IV., taken in order, beginning with the first:

Number 1. Is a short, roundish specimen, peculiar in having a surface much mottled with white, and the blossom end quite pointed and ribbed with white. Nearly spineless.

Number 2. Is remarkable for its large spines, somewbat curved, rather uniform in size throughout, and decidedly triangular in cross section. Very green at stem end, and quite pale-green and ribbed with white at the blossom end.

Number 3. Is somewhat similar to No. 2 in the number of spines, but is a greenish-white throughout, somewhat curved, and decidedly triangular in cross section, and larger at the stem end.

Number 4. Is with few large spines, very straight and plump and rather short. A light-green, strongly ribbed with white from the blossom end.

Number 5. Has very few small spines. Is larger at the blossom end. A pale-green throughout, with the exception of a tendency to be white-ribbed from the blossom end.

Number 6. Is white throughout, with few spines, very plump and slightly curved.

Number 7. Is remarkable in being exceedingly spiny. Dark-green at stem end, growing pale and becoming yellowish-green at the blossom end, with a tendency to be ribbed and quite triangular in cross section.

Number 8. Is nearly the shape of No. 1, but, in addition, is exceedingly spiny, with a strong tendency to mottling, with a light green, quite sharp-pointed at the blossom end.

Number 9. Is nearly free from spines. Is broadly boat-shaped, with large blotches of whitish-green upon the green background, with a tendency to be ribbed from the flower end.

Number 10. Is with few spines, and a deep green color throughout. Strongly triangular in section.

Number 11. Is free from spines, oval-shaped, and white throughout.

Number 12. Is somewhat spiny, long, dark-green, and somewhat club-shaped.

Number 13. Is almost without spines, and white throughout. Very broadly boat-shaped, nearly straight, and very handsome.

Number 14. Is with few spines. Very dark-green and long, and somewhat club-shaped.

Number 15. Is nearly spineless. Dark-green. Straight and uniform in all respects throughout.

Number 16. Is nearly spineless. Pale, greenish-yellow color throughout, and inclined to be club-shaped ; somewhat triangular in section.

Number 17. Is with very few spines. Intensely dark-green in color, nearly uniform throughout. Slightly curved, and with little tendency to be triangular.

EXPERIMENTS IN CROSSING EGGPLANTS.

The results of the first year with seedlings from the cross of the "NewYork Improved Spineless" variety npon the "Long Purple" of the previous season have been fully considered the present year. The greenhouse permitted the growing of plants of various ages for setting in the experiment grounds. One lot was started so early that some of the plants showed tbeir first bloom before they were set out, and an early crop of fruit obtained from these plants, followed by a second setting that corresponded in time with the main lot of plants grown at the usual time.

The cross was evident at a very early stage in the growth of the plants, first, from the uprightness of the "Long Purple" parent with the large broad leaf of the "New York Improved." There was the purple color of the young stems and leaf-stalk and mid-rib common to the "Long Purple," with the stoutness of the "New York Improved." Unusual vigor prevailed in the plants and a remarkable freedom from all leaf or root troubles, quite in contrast with plants of previous seasons upon adjoining plots. This was largely due to a more favorable year for this crop, as is proved by the check plants of both parent forms grown alongside of the cross.

When it came to the fruit the certainty of the cross was agreeahly confirmed, because, instead of the long, slender and usually curved form of the "Long Purple," or the oval shape of tbe "New York Improved," there was a fruit that combined tbe characteristics of the two. In color it agreed closely with the dark purple of the "Long Purple," and is perfection in that respect for the peculiar demands of the market. In general shape it was like a slender pear of the "Bartlett" or "Louise Bonne" type, with often a little curve, which feature may be due simply to the position the young fruit takes

between the ground upon which it rests and the branch above that bears it. While in weight it may not be heavier than the oval "New York Improved," it is often nearly twice as long, and therefore of a much superior shape for cooking. A large "egg" of the oval type is not well suited for the frying pan, while the new cross bears fruits that, when gathered at the right time, are just right for slicing and make pieces of the most convenient size for the table. The serious objections to the "Long Purple," as grown here for several years, has been their small size and lateness in coming into bearing and lack of fruitfulness. The quality is superior, and the small slices, when properly prepared, suggest strongly the oyster without their disagreeable features to those whose defective digestion is insufficient for the bivalve.

The "Long Purple" fruit has the seeds confined to its lower half, that is, in the free or lower end. In the "New York Improved" the seeds are more generally distributed throughout the fruit. The cross yields a long fruit, from which more than half of the slices taken are solid flesh, while the others are firm because the seeding tendency is not greatly developed.

The plants of this cross have proved of remarkable vigor, so great, in fact, that it has been suggested that for this reason alone the cross is a great gain. They began to yield marketable fruits by July 20th, while it was August 8th before fruit could be gathered from the "New York Improved." The crossed plants were practically one month earlier than the "New York Improved" and fully six weeks in advance of the "Long Purple." The latter were only beginning to flower by August 8th, and marketable fruits were rare until after September 10th.

The crossed and parent plants seemed to be equally affected by the fruit rot.

The greater gain of the cross is in the qualities found in the fruit already mentioned, namely, its perfect color, its desirable size and shape, being exceedingly attractive to the eye and permitting of convenient slicing for cooking, the large portion without seeds and possessing the high quality of the "Long Purple," with none of its defects.

It still remains to be determined whether the cross will maintain itself in the years to come. For the present, it can only be said that there has been but little variation from the shape mentioned. In fact, the whole lot of eggplants has yielded fruits as uniform as any of the old standard sorts the writer has seen. This does not preclude

the thought that the second year may see many variations, so that selection and further breeding may be necessary to fix the type. If this is found necessary, the attempt will be made to lengthen the fruits still more, so that they may stand on end as they grow, with less surface upon the earth to induce decay or attract worms, while at the same time increasing the percentage of seedless flesh in a suitable shape for ordinary purposes.

Plate V. shows in the upper half the cross-fruit, in the center, with the sample of "Long Purple" fruit upon the left and the "New York Improved" upon the right. It was immaterial which parent bore the seeds in the cross, as the results were quite uniformly the same. There is little that needs to be said in addition to the preceding remarks, for the results are well shown in the engraving.

The lower half gives the same fruits cut longitudinally through the center, to show the texture and seed-bearing capacity of the three forms. It is seen that the middle fruit shows a much larger amount of solid, seedless interior than either of the parents. This is partly due to the increased size over the "Long Purple," from which parent it received the tendency to freedom from seeds in the upper two-thirds of the fruit.

EXPERIMENTS IN CROSSING SWEET CORN WITH RED GRAINS.

Plot IV., Series VI., was again planted to sweet corn. For seed, the pink grains were used from eight ears of the previous crop, and all having over ten rows upon the cob. The planting was upon May 14th, and the fruit harvest September 23d. The whole plot was remarkable for the vigor and size of the plants, which rank among the large-sized sweet corns.

The first thing observed in the results of the year's work upon this plot is the greatly-increased amount of the red in the ears. The table below gives the number of grains of each color for five average ears :

	Uncolored.	Black.	Red.
	69	21	342
	35	140	205
	48	115	322
	215	110	179
	82	21	257
Average	90	81	261

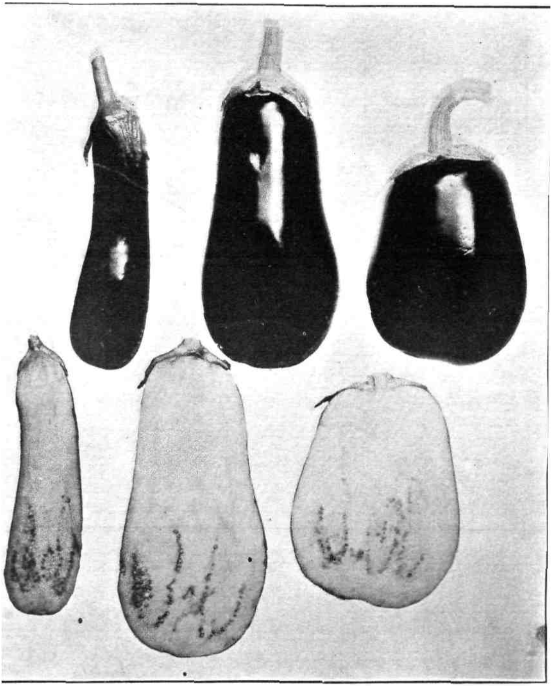


PLATE V.

Crossed Eggplants. Upper half is a surface view with section shown below. On the left is the "Long Purple," on the right, "New York Improved," and the Cross between them in the middle.

A similar count made the year before for the crop upon the same land gave :

	Uncolored.	Black.	Red.
Average (1900)........................	172	121	92

It is seen that the number of red (pink) colored grains has greatly increased, of course at the expense of the uncolored (white) and dark (black) grains. There is, however, an increase in the actual number of grains per ear of 47—a feature of no small consequence when many rows is considered an advantage in sweet corn.

A second point to be observed, in a study of the ears as a whole, is *the greater variation in them than last season. In 1900 the ears were* practically alike, five of which were shown in a plate in last year's report. This season they range all the way from those with about half white grains to ears in which the color was entirely red. A representative group is shown in Figure VI., where the ear upon the left represents the extreme for white grains and the one upon the right for red ones. The middle ear is as near an average in regard to color of grains as may be selected.

It was noted at the outset that pink grains for seed were selcted from ears with more than ten rows of grains. This selection may have influenced the ears, for nearly all of them are more than eight-*rowed, and in this respect the "Black Mexican" type is largely lost* from view. Ten per cent. of eight-rowed ears are still met with, but such ears seem to have no greater percentage of dark grains than others.

A noticeable feature this season is the number of ears that have only two sorts of grains, namely, the uncolored and a pecular bluish kind, that may be styled "lead-colored." That these ears have come from the darkest pink grains bordering upon purple is almost proved in other plots, where the so-called "black" grains were planted to determine the power in reproducing their kinds. This part of the subject is considered elsewhere. Some of the ears are *mixed purple or "lead-colored" and white, and others are entirely* of bright pink and white. In short, there are all variations between the two types named, which shows the great power each grain has of producing grains like itself, and this leads one to place great importance upon the selection of just that type of grain that is desired in the product. If this work of crossing corn had no other output than the enforcing of this underlying principle of plant improvement, it would not be fruitless indeed. The results are so rapid and cumu-

lative that every grower should look upon his seed as the factor in his work, largely under control, that makes for success or failure, as the case may be.

Plot I., Series 0, was devoted wholly to corn for the present season, excepting some late-planted squashes and cucumbers. The seed used was pink grains, selected from a dozen well-shaped, eight-rowed ears from Plot IV., Series VI., of the previous year. The harvest was concluded upon September 27th, and, upon making a close comparison with that of Plot IV., Series VI., previously reported, there was no difference to be found in the percentage of the various colors of grains, so that what was there stated holds with equal force here. The only difference between the two plots was that of the rows of grains upon the ears used for seed. Excepting this, that the plot now under consideration is a higher piece of land and not so rich in plant-food, and while there was not a great difference in size of plants and yield, they were in favor of the Plot IV., Series VI.

The following table shows the types, in rows, for one hundred ears for three plots, where the seed ears varied in number of rows:

	8-rowed seed.	10-rowed seed.	Over 10-rowed seed.
No. 8-rowed ears	26	36	21
" 10 " "	46	25	44
" 12 " "	27	37	31
" 14 " "	1	2	4
	100	100	100

	Average.
No. 8-rowed ears	28
" 10 " "	38
" 12 " "	32
" 14 " "	2
	100

From this it is seen that the greatest number of 8-rowed ears was from 10-rowed seed and the greatest number of 10-rowed ears was from the 8-rowed seed. The greatest percentage of 12-rowed ears was from the 10-rowed seed and the majority of the ears with over 10 rows was from the ears with 12 to 14 rows. Out of this single test one would not get much light upon the method for selecting for definite type as to number of rows to the ear. This is a feature in cross-bred corn that is quite different from that in color, for it is more deeply seated than mere color of the grain, that may be influenced by

the cross. While the "Black Mexican" is an 8-rowed variety, the "Egyptian" has no fully-established number over 8, and this variety has had a preponderance of influence upon the rows in the ear, as the table above indicates, where nearly three-fourths of the ears are with more than 8 rows. The same stalk may bear an 8, a 10 and a 12-rowed ear, showing that circumstances determine the number upon the same plant, and these may be entirely outside of the combination of the cross.

Plot IV., Series 0, was planted again to corn, this time with pink grains from 10-rowed ears. There is little to be added to what has been said concerning the results upon the two other plots planted with similar grains. There was quite a uniform increase of the pink grains over that of the previous year, and some ears were found with only red grains. The fact that grain for 10-rowed ears had no marked tendency to produce 10-rowed ears is mentioned elsewhere in tabular form. In this instance there were more 8-rowed and 12-rowed ears than those that were 10-rowed, like the parent ears. Several records of similar observations are necessary for the formation of any general rule that may hold in these cases.

A portion of Plot I., Series VI., was set with corn started in the greenhouse. The seed did not differ in kind from that used in the plots above mentioned. The corn did not grow for some weeks after being set in the field and made a small growth, but was a week or so earlier than in the other plots. The percentages of red grains and the number of rows to an ear were not different from those elsewhere. There was no decided gain in anything by thus starting the corn indoors and setting it out when four weeks old.

With White and Black Grains.

Plot I., Series IV., was planted to corn on June 28th, purposely late, to avoid mixing with the plots receiving the pink grains. The seed used was the white and the black grains from ears with over ten rows, the pink grains of which had been planted in Plot 2, Series VI.

The six eastern rows of the plot were planted with the white grains and the western six rows with the black grains. All else was in common, excepting that six of the white hills were covered with small tents at blooming time, and these are reported upon elsewhere. There was no difference in the plants between the two halves of the plot while growing; that is, the size of stalk, time of blooming, and color of leaf, were uniform.

The harvest was made on September 30th, and an average sample ear selected from each row. The outermost row planted with white grains showed about twenty per cent. of the dark grains, while the outside row, planted with black grains, gave practically the same number that were either white or off of the black color. Rows six and seven were adjoining, and upon the row planted with white grains the white predominated, and upon the other row the black led. The number of each color was as follows:

	White.	Pink.	Black.	Total.
Ear from white seed	330	33	93	456
Ear from black seed	178	49	193	420

It is seen that, while the mother plant controls the color, this is much more evident with the white than the black color. No notes were made upon the prevailing winds at the time of blooming, which might have favored one or the other side. The well-known fact of the readiness with which corn will cross finds a good illustration in the present instance.

Some of the grains, ranked as pink in the tabulation, are speckled or marked with bars of color; occasionally a half of the grain only is purple, so that some ears have a wide range of grains, in this respect indicating an unsettled condition of things.

A count was made of the best ears throughout the plot, and the following are the numbers for the various rows upon the cob:

	White seed.	Black seed.
No. of 8-rowed ears	15	15
" 10 " "	42	41
" 12 " "	58	74
" 14 " "	4	6

This shows a very large percentage for the 12-rowed type.

As the seed used in the plot is from the same ears as that for Plot IV., Series VI., all being over 10-rowed, a comparison with the harvest of that plot may be interesting, for which facts see previous page.

Inbreeding of the Crossed Corn.

During the present season an attempt has been made to inbreed corn. Of the lot of corn transplanted from the greenhouse to belts 1, 2 and 3 of Plot I., Series VI., five separate hills were thinned to a single stalk shortly before the time for the tassel to appear, and

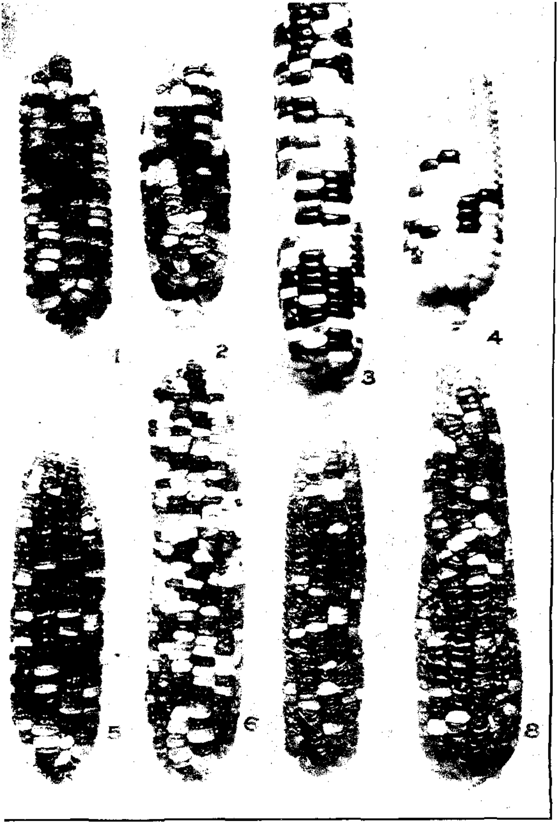


PLATE VII.

Inbred and Wide-bred Corn. The upper row shows inbred ears, Nos. 1 and 2 dry, and Nos. 3 and 4 green. The lower row shows ears from detasselled stalks.

covered with a "tent" made of cloth tacked to stakes that were driven in the ground. These "tents" were triangular, one foot upon each side, and everywhere made, as it seemed, pollen proof. In these enclosures the stalks remained for three weeks, the only attention given them being an almost daily jarring, to assist in the fall of the pollen that of course was shut in from the ordinary winds moving around them.

It was observed during the time the "tents" were in use that ordinary stalks in the open, comparable in every way with those covered, matured much more rapidly. While it is, for example, a well-observed fact that the tassel begins to show pollen in its lowermost branches some two or three days before the silks of the same stalk appear, in the confined stalks this period was increased to a week or even ten days. It was also noted that the silks of the "tented" stalks kept green and apparently receptive for a time, far exceeding that of the surrounding corn. Last season an experiment was made upon the duration of fresh corn-silk by removing all the tassels from a plot planted late, and therefore in bloom after all surrounding plots of corn had gone to seed. It was then demonstrated that silk deprived of pollen did not only grow to enormous size, but kept green for two or three times the normal period. The "tented" plants behaved in the same way as if the pollen did not reach it promptly, and this is probably true because of the confined condition of the plant under treatment. Good ears, however, did finally form in the "tents," as may be shown by those figured in Plate VII. No. 1 is as an ear from the corn started in the greenhouse above located in the field. No. 2 is a similar ear from a plant "tented" in the same way as before noted, but in Plot IV., Series VI., where the seed grain was planted in the field. These ears are both short, but well filled out with normal grains and with an admixture of white and pink and all the aspects of the ears of the crop of the previous season. In No. 3 is shown an ear obtained by covering the young ear before blooming, with a paper bag, while the tassel had been similarly treated some days before. When the silk was ready the bag containing the tassel cut from its stalk replaced the one that had previously protected the young ear. The latter large bag was kept in place until the corn had set. There seems to be very little opportunity of foreign pollination. The ear shown, one of several, is of fair size and is from a stalk that grew from a very dark grain. The mixture of grains is more distinctly black with white, not well shown in the engraving, as the photograph of this No. 4 being taken

when the ear was freshly picked and the grains were plump. No. 4 differs from the preceding only in being from a white grain of the mixed corn, and nearly all the ear is of the same color.

There were seventeen separate stalks placed in "tents" at different dates, and a majority of them produced ears, while others failed, probably because a mould attacked the pollen during a wet spell. So bad was this upon some stalks that it is a wonder that any ears formed. The "tents" might be improved by being extended a foot or more above the tassel and a larger diameter of the whole would add needed space.

The conclusion seems to be that inbred corn reproduces the peculiarities of the stock; that is, a pink grain from a mixed ear produces a mixed ear, but at the same time a black grain from the same mixed ear shows an increase in the black and a white grain an increase of the white. The immediate parent, while having an influence, does not control the offspring.

Wide Pollination in Crossed Corn.

As opposed to the tests in inbreeding, at the same time that stalks were placed in "tents," certain others in the same plots and closely comparable with them were detasseled, and therefore the possibility of inbreeding destroyed.

Ears Nos. 5, 6, 7 and 8, in Plate VII., are from such castrated stalks from four different plots. In this instance it seems evident that the removal of the tassel at a time when it is issuing from its coil of leaves is injurious to the plant. With the exception of No. 6, none of the ears shown are first-class. The cut stalks seemed to brown at the top and cease growing, and, of course, they lost some leaf surface by the decapitation. None of the ears filled out well and were not even in breadth, as is evident in Nos. 7 and 8. All four ears shown were from the same stock of pink grains and they do not differ in percentage of pink and white grains from those grown normally around them. No. 6 is somewhat lighter than the average and the other three are perhaps a trifle darker, so that a fair average is maintained.

Nothing in this test goes counter to the generally accepted belief that pollination between different plants is the rule with corn, for which there is ample provision in the high position of the tassel, the great abundance of dust-like pollen and the silks of any given plant maturing somewhat later than its own tassel.

Breeding of Corn for Prolificness.

A half plot (in Plot III., Series IV.) was planted late, June 28th, with the pink grains selected from the seven ears taken from three stalks grown in Plot IV., Series VI., of the previous year. One of the stalks bore three fine ears and the other four of the seven ears were first-grade twins. There were but few triplets in the original plot, while the twins were not rare. The triplet had two ears, with ten rows of grains and one ear with fourteen rows. One of the twins had eight and ten rows to the ear respectively, while the other pair were both 12-rowed. Therefore, of the seven ears one was 8-rowed, three were 10-rowed, two 12-rowed and one 14-rowed, or an average of eleven rows to the ear.

The corn made a fine growth of stalk, and in size it was entirely satisfactory in this respect. Owing to late planting the season was shortened, but the absence of early frosts favored the experiment, and the corn was harvested upon October 13th, at which time the grains on many ears had begun to shrivel.

There were six rows of eight hills each, or 48 hills, carrying 144 stalks, omitting the many "suckers," some of which grew tall and produced small ears not considered in the count. There were 44 stalks with single ears, these being unusually large and invariably with ten or more rows of grains. Eighty-three stalks had two large, marketable ears, with rarely less than ten rows, and one was a pair of 16-rowed ears. There were 17 with three or more ears, among these being one stalk with five ears, all over five inches long, and one with six and another with seven ears, but of these only one or two were marketable. The tendency to produce ears had thwarted the end and stalks had formed, which were not at all desirable.

The table of the number of rows to an ear for seven sets of triplets :

	Stalk 1.	Stalk 2.	Stalk 3.	Stalk 4.	Stalk 5.	Stalk 6.	Stalk 7.	Total rows.
Upper ear...........	8	12	8	10	10	12	8	68
Middle ear.........	12	8	10	10	10	12	10	72
Lower ear..........	12	8	12	10	8	12	8	70

This shows that the average number of rows does not vary much for each position upon the stalk. The upper ear may have the smallest number of rows, as in No. 1, or the largest, as in No. 2. The number may be the same for all the ears, as in Nos. 4 and 5, or the middle ear may have the largest number, as in No. 7. The average number for the twenty-one ears tabulated is exactly 10, which is one row less than that in the lot of seven ears that furnished the seed for

the planting. This is true, however, that the ears borne singly in this lot gave a higher average than the triplets above tabulated, and the same is true of the pairs of ears, so that the average of the number of rows is brought up to fully that of the seed ears, and the experiment shows clearly that the grains from ears with many rows have a tendency to produce ears similar to those furnishing the seed.

This is only an incidental fact, and the still more important one is the exhibition of the tendency to ear formation. This is made more evident when it is stated that upon all the other plots of corn in all 432 hills, not a single triplet was found, and comparatively few twins. In order to get the required amount of the ears desired no attempt to use twin ears was possible. It is regretted that the number of twins was not recorded, but, as stated, they were not common. On the other hand, in the half plot in question, where two twins and a triplet were used for seed, the number of ears was 272, or nearly an average of two ears to the stalk, exclusive of many "suckers" that sometimes eared at the tip in a cluster of grain-bearing spikes.

FURTHER OBSERVATIONS UPON SALSIFY HYBRIDS.

In the report for last year (pages 445–447) the results up to that time are given upon the work in the crossing common garden salsify, or "oyster plant," *Tragopogon porrifolius* L., with the wild species, *T. pratensis* L. The hybrid plants, twelve in all, seeded sparingly, and these seeds were sown in Plot I., Series VI; but owing to the unfavorable dry weather the autumn growth was not as it might have otherwise been. The seeds from each hybrid plant were sown in separate rows, that any differences in the offspring might be noted.

The two parent species, while agreeing closely in many things, are strikingly different in the color of the flowers, those of the cultivated salsify being light violet red violet*, while that of the wild species is deep yellow.

It is seen, therefore, that in one parent the floral colors are a mixture of violet and red, the violet predominating, while the other is a simple yellow. There are two types of the crossed plants as regards the color of the inflorescences, namely, (1) with both the ray and the central flowers all colored alike, darker red, red violet, and (2) those with only the ray flowers, the above color, while the smaller central flowers are yellow, excepting possibly the tops of the ligulate corollas; in short, the central flowers closely agree with those of the male parent. This second type favors the wild species, and the first

*In this record, Prang's color chart is employed.

type approaches the cultivated form. There were no intermediates between the two above types. It is seen that in the crosses the violet has diminished, while the red has greatly increased and the yellow is scarcely in evidence in one of the types.

Plants in large numbers from these hybrid seeds have been observed this season, and the range in colors is a wide one, no less than thirty-five of those in Prang's list being present.

Starting with the red end of the spectrum, the number of blooms examined at two different dates (June 1st and 8th) follows the name given to the color matched with the flowers.

	Color chart number.	Color.	Abbreviation.	June 1.	June 8.	Total.
	11	Darker red	(R-dd)	7	16	23
	12	Dark red	(R-d)	7	6	13
	22	Dark red red orange	(RRO-d	1	...	1
	31	Darker red orange	(RO-dd)	4	2	6
	41	Darker orange red orange	(ORO-dd	6	3	9
	82	Dark yellow yellow orange	(YYO-d	1	...	1
	83	Yellow yellow orange	(YYO)	1	...	1
	92	Dark yellow	(Y-d)	1	1	2
Parent	93*	Yellow	(Y)	5	5	10
	94	Light yellow	(Y-l)	6	6	12
	95	Lighter yellow	(Y-ll)	2	4	6
	101	Darker yellow yellow green	(YYG-dd)	1	...	1
	212	Dark violet	(V-d)	1	...	1
	213*	Violet	(V)	3	...	3
	214	Light violet	(V-L)	2	...	2
	215	Lighter violet	(V-Ll)	1	...	1
	222	Dark violet red violet	(VRV-d)	...	...	...
	223*	Violet red violet	(VRV)	13	10	23
Parent	224	Light violet red violet	(VRV-L)	23	12	35
	225	Lighter violet red violet	(VRV-Ll)	14	15	29
	232	Dark red violet	(RV-d)	1	1	2
	233*	Red violet		3	2	5
	234	Light red violet		4	5	9
	235	Lighter red violet		...	...	...
Hybrid	241	Darker red red violet		3	...	3
	242	Dark red red violet		1	2	3
	243*	Red red violet		1	1	2
	252	Dark orange gray		1	2	3
	253	Orange gray or brown		3	...	3
	331	Darker red gray		1	...	1
	333	Red gray or russet		3	...	3
	354	Light yellow gray		1	...	1
	375	Lighter blue gray		1	...	1
	382	Dark violet gray		6	...	6
	384	Light violet gray		1	...	1

It is seen that the color of the *T. porrifolius* has the largest number, with its nearest neighboring shades as next largest. The dark reds follow closely. In short, the violets and reds predominate, while in the yellow there is a fair showing.

During the present season the seedlings of no one mother plant differed in any particular way from others. They all showed equally the wide variation in the colors of the flowers that has been detailed in the table.

The piece of ground bearing the hybrids is left with the plants to self-seed the land, that a study may be made of the persistency of the forms when growing, as nearly as possible, in a state of nature.

Whether a drifting back to one or the other, or both parents, will take place, or instead, a new hybrid species will come into existence, is one of those questions that is not answered by philosophy, but by the action of the surrounding influences, in combination with the internal forces upon a confused and interblended stream of life currents.

Plot II., Series III., was sown to salsify, the seed in alternate rows being from the plot where hybrids occurred the previous season, and natural mixing was to be expected. There were but few plants among all these suspects that proved to be hybrids, and these were invariably in the rows with the cultivated species. These hybrids, similar to those of 1900, were of two types, previously described, and were large in size and enormous bloomers. The seeds of these plants were sown in mid-summer for a second plot of seedling hybrids, and have made a good stand for passing the winter.

A large amount of artificial crossing was done with the rows of the two parent species, that the stock of the hybrid may be so far increased next year that the roots may be tested as to their merit as an article of food.*

Other Crossing.

Two species of Martynia have been grown the present season for the purpose of hybridizing. Several fruits were obtained between *Martynia Louisiana* Mill. and *M. lutea*, with the former as the mother plant; but the three fruits upon the latter parent were too young when the frosts came to give viable seeds. What this union of two

* Some of the above facts were given by the writer in a paper before Section G, American Association for the Advancement of Science, at its meeting at Denver, Colo., in August.

quite different species may produce is a matter for the future, but possibly an acceptable pickle may result.

Many attempts were made to cross the trumpet creeper (*Tecoma radicans* (L.) upon the Martynia, but without success. While closely related, and in many peculiarities the same, one is a hardy vine and the other a tender herb, a combination of which characteristics one is not likely to secure.

The breeding together of the ordinary field flax (*Linum usitatissimum L.*, and the ornamental species *L.*, *grandiflorum L.* (?), has been attempted, and several full-sized seed vessels were secured upon the latter species; they all but one proved to be seedless. In this instance the two species are widely separated in this, that the blue flax of the field has all its sex organs alike; but in the scarlet species of the gardens there are two lengths of the female organs. Plants with sex organs thus developed are combined with difficulty with other species. It is said that plants of one form of pistils are sterile to their own form and need the pollen of the other form of flower for fecundation. If this is the case it only heightens one's desire to effect the cross, if it is a possible thing.

PLANT BREEDING AND IMPROVEMENT IN OUR EXPERIMENT STATIONS.

The following is an abstract of a paper read at New Haven, Conn., November 12th, 1900: *

A brief letter of inquiry was sent to each Experiment Station, and from the fifty stations now on the official list reports were received as follows: Alabama, Arizona, Arkansas, California, Colorado, Connecticut (New Haven and Storrs), Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Lousiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York (Geneva), New York (Cornell), North Carolina, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Washington, Wisconsin, Wyoming.

The list of Experiment Station responses are taken up alphabetically, omiting those reporting no work in plant breeding and selection.

Alabama.—Bulletin 56, May, 1894, is upon "Crossing for the Purpose of Improving the Cotton Fibre;" Bulletin 71, April, 1896, is

*The fourteenth annual convention of the Association of American Agricultural Colleges and Experiment Stations.

"Experiments with Foreign Cottons," and Bulletin 83, June, 1897, has for its title "Hybrids from American and Foreign Cottons." "The combination of the *Gossypium hirsutum* and *Gossypium mantimum* yields a cotton plant which produces fibre of the best grade in strength, maturity, twist, length, fineness and yield per acre." * * *

California.—"In answer, etc., * * * for our work in the origination of new varieties by crossing, etc., we can only confess to have done nothing, nor have we published anything on the subject. Mr. Burbank, Judge Logan and Mr. C. P. Taft, of Orange; Mrs. Shepherd, of Ventura, and others, have undertaken much in this line, as you know, and because of the activity of private propagators we have given very little attention to the subject."

Connecticut.—Mr. J. B. Olcott, of Connecticut, was at one time strongly advocating the improvement of lawns by a method of grass cuttings, thus producing a uniform turf of the same strain of grass.

Georgia.—"Some years ago we did a good deal of work in crossing varieties of cotton."

Illinois.—Bulletin No. 21 gives the results of Mr. McClure in the crossing of corn, and Bulletins Nos. 53 and 55 report the work of Professor Hipkins in selection with reference to the chemical composition of corn. Considerable work has been done upon inbreeding of corn. Three generations of inbreeding results in almost sterility, the first generation showing a degree of unproductiveness that would practically amount to the ruin of a crop. So pronounced is this result of even the first generation from inbreeding that we are led to wonder if this is not the practical cause of barren stalks, which in this country amount ofttimes to 20 per cent. of the crop.

The results of Mr. McClure's work are briefly summarized as follows: "In 1889 sixteen crosses in corn were produced; in 1890 one hundred and fifty-eight." Among other things the results indicated "that corn grown from crossing two distinct varieties will be larger than the average of the kinds crossed, or when the parents are nearly equal larger than either."

Indiana.—For many years we have grown with much care a variety of yellow dent corn, which is known as "Purdue yellow dent."

Iowa.—Bulletin 14, August, 1891, is upon "Breeding of the Orchard and Garden Fruits," in which notes upon seedling crosses of apples are recorded. Bulletin 22 (1893) contains a section upon "Rosa Hybrids," which were of the Russian type of *Rosa rugosa* as the pistillate parent with "General Jacqeminot," "American Beauty," and other standard roses, the hope being a double hardy

rose for the prairie region. In Bulletin 32 (1896), Professors Budd and Hansen report upon "Some of Our Advances in Breeding Fruits and Shrubs," and figure new hybrid roses of great promise. Hybrid strawberries, grapes, plums, pears, apples, are also considered. In Bulletin 36 (1897), under "Hybrid roses, gooseberries and strawberries," Professor Budd shows still further advances, and an engraving of a heavily-fruited hybrid between a wild gooseberry of Manitoba and the "Champion."

Kansas—Professor Kellerman, assisted by Mr. Swingle, began the crossing of field corn at the Kansas Station in 1888. From the report for the next year, 1889, the following: "The effect of crossing could always be plainly seen the second year, whether visible the first year or not. The crosses * * * were generally of two types: (1) those in which the kernels were uniform, and (2) those in which they were variable." From Bulletin 17, December, 1890, it is gathered that "The product of the third year is generally true to the seed planted." Forty-nine crosses of 1890 were planted in 1891, and of the 33 harvested, 25 showed intermediate characteristics between the parents. The bulletin concludes with the following statement: "The characters secured by crossing can be retained."

Louisiana.—From Bulletin 26, February, 1894, it is gathered that three years earlier, "Some stalks of cane, partly white and partly purple, were selected from the field of Soniat Brothers' Tchoupitoulas plantation. They were called by them bastard canes. These stalks were planted as follows: First row, the entire stalk; second row, the white joints of each stalk; third row, the colored joints of each stalk. At the end of the season, four distinct canes, as far as color could direct us, were obtained." By selection, the varieties have become fixed, received names and "are different from any other in our collection."

Maine.—It is gathered from the reports of 1893, 1894 and 1896 that much work has been done in improving tomatoes, and particularly through a species hybrid between the ordinary form (*Lycopersicum esculentum* Miller) and the current tomato (*L. pimpinellifolium* Dunal), the latter bearing small fruits in racemes like currants. By blending these two species, the "Lorillard," a standard forcing variety, being used with the current, and selecting and furthermore uniting the hydrid with the "Lorillard" again, the fruit has been brought up to an acceptable market size and the quantity much increased.

Maryland.—Considerable work is in progress along breeding lines in both the Horticultural and Agricultural Divisions, but nothing has been printed.

Massachusetts.—They have hundreds of seedling strawberries, seedling raspberries, some of which show great merit, and seedling strawberries, some of which are of great promise. A lot of seedling plums not tested in California have been sent to them by Luther Burbank for trial and distribution, the entire stock being in their hands.

Michigan.—From the bulletins and reports it is gathered that a large amount of work is done at the central and sub-station upon the trial of varieties of fruit and vegetables and their improvement through selection. In the earlier days of the Agricultural College some crossing and hybridizing was accomplished, in tomatoes in particular, by Professor Bailey, before he went to Cornell University.

Minnesota.—Bulletin 62 has been received upon "Wheat Varieties Breeding, Cultivation." Professor Hay, the author, is one of the leading breeders of cereals on this continent, with a rival of significance along his line in Dr. Wm. Saunders, of the Experimental Farms, Ottawa, Canada. As early as 1889 Professor Hay published from the Minnesota Station, bulletin 7, upon "Improving Corn by Cross-fertilization and Selection," The following facts are taken from the summary of the bulletin recently issued : "Hybrids vary greatly in yield, in grade or quality, in rust resistance. * * * By systematic selection of * * * hybridized wheats, improved varieties are originated at slight cost. * * * Three out of thirty varieties, first originated by selection, are being disseminated, and seven new hybrids are very promising."

Mississippi.—Did considerable work in crossing some of the "Egyptian" varieties of cotton with our native sorts.

Missouri.—Here they have two varieties of seedling strawberries not yet named—promise to have much commercial value. They are also working on radishes and plums.

Nebraska.—The Professor of Horticulture kindly referred me to the thirteenth annual report, where it was found that "Work has begun in improving the sand cherry by selection, * * * by hybridization with cultivated plums and cherries. The wild plums are being treated in much the same way." The wild black raspberry and wild grape are being considered, and the hybridization of beans and of watermelons are going forward, while a co-operative experiment in corn breeding with Dr. Webber, Chief of Section of Plant Breeding of the United States Department of Agriculture, is well projected.

Aside from the work noted in the report referred to, by letter it is learned that this division has recently begun an important piece of work along the line of the production of new varieties of apples by means of hybridization.

New Jersey.—Some work is being done in the breeding of truck crops, particularly beans, eggplants, tomatoes and sweet corn. Nothing is yet ready for distribution. A hybrid has been secured between two species of salsify, that shows great vigor and may prove less liable to the white mould than the old garden form.

New Mexico.—"In the earlier part of the history of the Station an attempt was made of originating varieties of wheat by crossing. In 1898 cross-pollination was performed with the 'Wolf' and 'Yellow Egg' plums."

New York (Geneva).—"This Station has given more or less attention to plant improvement by crossing, etc., since 1883. About that time Prof. Godd originated the 'Station' pea, which is regularly listed by some seedsmen, and the 'Station' tomato. Since 1893 the work with strawberries has been continued till the present. Only one variety has been disseminated for trial, viz., the 'Hunn.' Particular study is given to the improvement of grapes and in fixing certain characters. This work is fundamental and preliminary to any marked advance in the improvement of this fruit. Some attention is paid to apples and pears, also gooseberries and currants. At the close of 1889 the inventory showed the following Station seedlings under test: Apples, 81; pears, 39; apricots, 5; cherry, 1; peach, 16; plum, 42; grape, 636; currants, 53; gooseberries, 680; hlack and dewberries, 182; raspberries, 958; strawberries, 429; total, 3,122. To this list were added, in 1900, apples, 65; pears, 35, and something over 3,000 grapes. A few were discarded, but the present number of Station seedlings under test is more than 6,000. Many hundreds in past years have been discarded.

"The one who, of all others, has been the leader in point of time and amount of work in the breeding of corn is the late lamented Dr. E. L. Sturtevant, who, as early as 1883, in the second report of the New York (Geneva) Experiment Station, recorded much study of, and tests made with, the crossing of corn. Each annual report for several years contained details of the hybrid corns, with observations upon the same."

New York (Cornell).—In the horticultural department they have made rather extensive studies, for many years, of plant-breeding, but for the purpose of arriving at the principles which underlie the

subject rather than producing new varieties. Only one commercial variety have we sent out, and that is the "Ignotum" tomato, a rather full history of which you will find in the latter part of Bailey's "Survival of the Unlike," and also in "Plant-Breeding." They have produced at least one thousand varieties of pumpkins and squashes, none of which, however, were of sufficient commercial importance to be introduced. They have made great numbers of crosses with flowers, fruits and other things, but not for the purpose or originating varieties which could not be propagated and named. The original desire was to make varieties of fruits and vegetables, but it soon changed for the more important one of arriving at principles first, as there seems to be a lack of comprehension of this subject in the public mind.

North Carolina.—The principal success heretofore has been in the growing of a great variety of colors of the popular shrub, generally known as "Crape Myrtle." They are also working toward getting a tomato more resistant to the Southern bacterial blight, starting with the little cherry and plum sorts that are the most resistant. They have also a new eggplant, that seems resistant to this blight. In the way of garden vegetables they are at work trying to produce a lettuce that will suit the winter gardeners better than any they now have.

Oregon.—The work has been undertaken along the line of fruits and flowers only. They have a very promising pear, that was crossed several years ago with the "Winter Nelis" and "Bartlett." The tree has borne fruit this year, and has the qualities of the two parents. They have fifteen crosses of roses and a number of good crosses of the pelargonium.

Rhode Island.—In the horticultural department strawberries and beans have been experimented with. The selection of bush fruits is also underway here. The agricultural division is investigating the peculiar characteristics of the corn-plant, and will endeavor to determine, if possible, what characteristics of the stalk, leaves, etc., are correlated with the best yield of seed. An attempt is being made to establish a standard for the corn-plant, at least of two varieties, and to breed to it for improvement. Similar work is being carried on in studying the characteristics and seeking to improve the yields of several varieties of timothy, wheat and rye. An attempt is also being made to secure, by selection and breeding, strains of several varieties of soja beans and cow peas in the endeavor to secure plants

which will be especially adapted to the soil and climatic conditions of Rhode Island.

South Carolina.—The only work in the lines mentioned has consisted in producing new varieties of cotton from artificial cross-breed-breeding and by hybridizing the *Gossypium Barbadense* and *G. herbarium.* In both lines they have succeeded in producing cotton superior to either parent.

South Dakota.—Several hundred crosses were effected this year, the work being outlined as follows: (*a*) Crossing of several Russian wheats on fife and blue stems; (*b*) selections from both the blue stems and the fifes; (*c*) the crossing of spelt and barley and spelt and hard wheat; (*d*) selections from spelts, oats, barley and corn; (*e*) the crossing of the two best varieties of field peas; (*f*) the crossing of our two most promising varieties of corn; (*g*) work has also been begun on clover, Turkestan alfalfa, about twenty species of grasses and the species of salt bush.

The lines of work in the Horticultural Department may be summarized as follows: 1. The breeding of native fruits by selection and crossing. 2. The breeding of apples and plums. 3. The breeding of an extra early smooth tomato by crossing and selection. 4. Hardy stocks for the orchard fruits. 5. Cultural and variety tests of vegetables and fruits. 6. Hardy hedge and ornamental plants. 7. Forestry and tree-plants.

Washington.—They have begun the improvements of wheat, both by crossing and by selection, and are attempting to produce winter wheats that will stand if on rich soil, will not shatter out with handling, have white grain, no beards, yield well, and resist bunt. In selecting, they are working with two distinct objects in view; the first is to improve standard varieties; the second is to determine the effect of continued selection in any given direction. For the latter, characters are chosen that easily show the effect of selection when there are effects, such as breeding beards upon bald wheat, and *vice versa;* breeding rufus chaff from white, etc.

Wisconsin.—They have been at work for several years past in seeking to improve the varieties of the native plum, the apple, the Missouri currant (*Ribes aureum*) and the dwarf Rocky Mountain cherry (*Prunus beeseyii*). They have also commenced some work with wild black cherry (*Prunus serotina*). They are doing this work chiefly by growing seedlings. In the apple they have planted selected varieties in an isolated place, with the express intention of planting the seeds from all the fruits that grow on the trees. In the native plum they

are planting seeds from trees that are located to favor cross-fertilization. In the wild black cherry they have started with the finest wild variety that they have been able to find, and hope to secure a fruit large enough to have commercial value.

In the above digest of the results of our Experiment Stations in plant-breeding it has not been the intention to include all the work done along the above line in the United States. Much has been accomplished by persons who were not associated with Experiment Stations and Agricultural Colleges, and, in fact, did their work even before these institutions came into existence. In this connection one first recalls the development of our American grapes and the infusion into them of the European blood, and call to mind the names of Bull, Rogers, Haskell, Ricketts and Moore, of the East, while Rommel, Jaeger and Munson have labored faithfully in the Southwest. These and others have already made America famous for its long list of varieties of superior cross-bred grapes.

Among pears we have blended the blood of the common with the Chinese species, and obtained varieties that have made pear-growing possible, if not very profitable, over a wide region where it was precarious before. The names of Keiffer and Leconte will be associated with these excellent results in hybridization.

The fact that the ordinary varieties of Eastern apples were not hardy in the great, cold Northwest, early led to importation from Russia, and the crossing of the common species with the Siberian Crab, the good results of which are still in store for the people of the twentieth century. For similar reasons the native plums in the West and South have been placed under culture and bred with the European types. Along with this is the advent of the Japanese plums and the formation of a group of hybrids, that places the name of Luther Burbank among the word's great horticultural benefactors.

Less distinct from the Experiment Stations than many of the plant-breeding enterprises included in the above general remarks is the work upon the citrus fruits by Messrs. Webber and Swingle, of the United States Department of Agriculture. The "Florida freeze," from which catastrophe the orange growers now date all passing events, aroused the government to the point of seeking for a more hardy orange, and the hybridizers are well on their way to produce it.

Space does not permit of more than a passing allusion to the hundreds of florists who are constantly keeping American floriculture in the van, particularly as to new crosses of carnations, chrysanthemums and roses.

For the last few remarks I am indebted, in part, to the excellent paper, "Hybridization in the United States," by Professor Bailey, in the recently-issued report of the Hybrid Conference, held at Cheswick and London, in July of last year, at which Professors Webber, Swingle and Hays took part, and besides, Professor Bailey, Dr. Macfarland and Mr. Thomas Meehan sent papers. In this world's conference upon a world-wide subject, the United States took its full share of honors.

It now remains for the Experiment Stations to follow up the work so well begun, and remember that he who improves the plants of a country improves its products and its people.

EXPERIMENTS WITH SALAD PLANTS.

Swiss Chard was grown in belts 4, 5 and 6, Plot IV., Series V., sown early (May 13th), while two belts elsewhere (Plot II., Series V.) were sown late (July 28th). Both sowings grew well and furnished an abundance of the leaf stalks. The early lot was somewhat affected with the leaf blight (*Cercospora beticola* Sacc.), while that sown late was nearly free. This verifies the results of former years, that the blight does not flourish upon the late-grown plants, and those who wish an abundance of a wholesome pod herb can obtain it from Swiss Chard when the seed is sown in ordinary soil as late as the 1st of August. Some plants that had been removed to the greenhouse in autumn, and after furnishing leaf stalks through the winter, were again taken to the field, where they made a fine early growth. This test shows that the Swiss Chard is easily handled, and when there is opportunity for continuing the growth indoors it can furnish acceptable greens during winter.

Some attempts were made to test this salad in the city market and with reasonable success. Nearly all who used it were desirous of getting more.

New Zealand Spinach.—A few plants of New Zealand spinach were taken from the greenhouse to the trial grounds in early spring; elsewhere seed was sown at the same time. The plants thrived and furnished throughout the hottest weather an abundance of tender leaves and tips of stems. While the plants from the greenhouse covered the ground rapidly, those from seeds were fully as large in September.

This is an excellent salad plant, that is worthy of attention by every one with a garden and a fondness for greens throughout the season.

Parsley.—Two varieties were grown in small quantity and both thrived and made fine plants. It transplants readily, and the field-grown plants may be treated as above mentioned for the chard.

EXPERIMENTS WITH WEEDS.

The piece of ground, 11 by 33 feet, called "the weed belt," has been continued for the fifth season. Plants have grown wild, ripened their seeds and scattered them as in a wild state. The following is the list of fourteen species most prominent during the year :

1. *Rumex acetosella* L. (0), (7), (4), (1).
2. *Bromus racemosus* L.
3. *Abutilon Abutilon* L. (7), (2), (6).
4. *Polygonum Pennsylvanicum* L. (6), (3), (2).
5. *Daucus Carota* L. (12), (0), (0), (4).
6. *Chrysanthemum Leucanthemum* L. (0), (0), (0), (9).
7. *Silene noctiflora* L. (9), (13), (14), (7).
8. *Taraxacum Taraxacum* L. (0), (0), (9), (5).
9. *Convolvulus arvensis* L.
10. *Melilotus alba* L. (0), (0), (0), (12).
11. *Oxalis stricta* L. (0), (0), (0), (8).
12. *Plantago lanceolata* L. (0), (0), (11), (10).
13. *Rudbeckia hirta* L.
14. *Ambrosia artemisæfolia* L. (3), (5), (1), (1).

It is seen that there are three new species upon the list, and of the eleven old ones many have changed places. A brome-grass, the field bindweed and yellow daisy are the ones that have come toward the front, while the ragweed, for example, has dropped from the head to the foot of the list. The smartweed, velvet leaf, wild carrot and catchfly are all near their places for 1900.

There are many competitors not in the above list, among which the following are mentioned :

Three kinds of clover—white, alsike and red ; five kinds of grasses—timothy, foxtail, redtop, a poa and a fescue ; dock, mercury, goose-foot, four asters, burdock, flea bane, salsify both cultivated and wild, broad plantain, asparagus, tomato, young grape vine and small cherry tree.

One of the things observed is the tendency for the ground to become covered with a growth of low plants, as the clovers and grasses and bindweed ; along with this there is a formation of a second layer of foliage, represented by the sweet clover, yellow daisy, velvet leaf and smartweed. Above this will be the cherry tree and the grape vine, providing the latter reaches the tree, as it is very likely to do in time.

EXPERIMENTS WITH LAWN GRASSES.

The nine plots of grass selected in the spring of 1896 have been kept closely cut with lawn mower during each season, and notes made from time to time upon the condition of each plot. The following table shows the species of seed sown in each plot and the condition of the stand of grass, in percentage, for the past six years :

	1896.	1897.	1898.	1899.	1900.	1901.
Plot 1. Meadow Fescue (*Festuca pratensis* Huds.)....	90	50	40	45	55	60
" 2. Fine-leaved Fescue (*Festuca tenuifolia* Sib.)..	5	50	40	40	40	45
" 3. Sheep's Fescue (*Festuca ovina* L.)..	10	50	40	40	30	25
" 4. Rhode Island Bent (*Agrostis canina* L.)	80	80	90	90	90	95
" 5. Wood Meadow (*Poa nemoralis* L.)............	60	65	70	85	80	85
" 6. Kentucky Blue (*Poa pratensis* L.)............	50	65	90	90	85	85
" 7. Rough Meadow (*Poa trivalis* L.)...............	90	65	70	70	45	70
" 8. Redtop (*Agrostis alba vulgaris* With.)	100	90	70	60	25	25
" 9. Perennial Rye (*Lolium perenne* L.)......	100	85	70	40	20	15

It is seen that the "Rhode Island Bent" holds up well, and the stand, this autumn, at time of last inspection, was approaching perfection. In the dry weeks of summer it becomes brown, and for this reason the present rating may be high. It is exceptionally fine in texture. The "Kentucky Blue Grass" has proved very satisfactory for the last three years, but some weeds have crept in the present season. In the "Wood Meadow" plot the grass has held its third place for three seasons. The "Meadow Fescue" has made a gain this dry season over the previous year, and, being at one end of the row of plots, is favored by a border gutter along one side of the plot. The "Redtop" shows a poor stand and the "Perennial Rye Grass" is nearly gone out. The leading weed in autumn is the crab grass, that fills in all vacancies.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

The following ornamental plants were grown this year, several for the sixth successive season :

Chrysanthemum.—A type of hardy chrysanthemum has been grown in the Experiment Area for several years and uniformly free from the rust (*Puccinia Hieracii* Mart.), that has been so destructive to the greenhouse chrysanthemums. Last year it was stated in the annual report that Mr. Kelsey found the rust upon some plants in a florist's garden. The present season a plant of this affected sort was set in

the midst of the chrysanthemums in our Experiment Area, with the result that the rust is now to be found upon the plants that for years have been free from the disease. That this is the same species of rust now so troublesome indoors is still a question, and as only one stage of the fungus is found its exact species is not determined. Last year some of the original plants were removed to a place nearly a mile away, and these remained free from the disease.

Pæonias.—The plants are gradually increasing in size. Hot, dry summer weather injures the foliage somewhat; otherwise they are fine.

Japanese Redbud.—Some of the trees have died, the winters being too severe for them. The foliage is too tender for our most trying summer weather. A cross with the native species is in mind, to overcome the weakness and yet preserve the good qualities of the dwarf tree, that blooms so handsomely in early spring.

Hibiscus.—Much thinning out of the plants was required this spring. Some of the crosses made previously were in bloom.

Cannas.—The row of cannas added a brilliant display to the ornamental portion of the Experiment Area. Several seedlings, some of special worth, came into bloom.

Nasturtiums.—Only the large form was grown this season, and, as before, showed tbe scorching of foliage mentioned in previous reports. Shading on the hottest days is a great advantage.

Mignonette.—Several forms of this were grown with a varying amount of the leaf spot.

Petunias.—A few plants of petunias were grown and gave a profusion of blooms throughout the season, with no showing of any sort of disease.

Verbenas.—In connection with a study of a mildew, two lots of verbenas were kept among the ornamental plants. They maintained their good name for abundant flowers during the autumn months.

EXPERIMENTS WITH PHLOXES AND THEIR ALLIES.

Belts 4, 5 and 6, of both Plots II. and III., of Series VI., were occupied with several kinds of plants, all of the natural family of Polemoniaceæ, of which the garden phlox is a prominent member. The following plan shows the arrangement of the plants, placed in rows running the short way of the belts; that is, the rows were eleven feet

HALF PLOT II.—*Phlox Drummondii* and *Cobœa.*

No.	Belt 4.	No.	Belt 5.	No.	Belt 6.
1	Chamois rose.	10	Kermesia.		Cobœa scandens blue.
2	Variabilis atropurpurea.	11	Rodowitzii.		" macrostemma.
3	Atropurperea stricta.	12	Cuspidata.		" scandens alba.
4	Coccinea.	13	Kermesia splendens.	19	Coccinea.
5	Leopoldi.	14	Occulta alba.	20	Black warrior.
6	Eclipse.	15	Alba.	21	Stellata splendins.
7	Rosea.	16	Mixed.	22	Mixed.
8	Half-dwarf bouquet.	17	Half-dwarf blood red.	23	Dwarf snow ball.
9	Dwarf surprise.	18	Fancy mixed.	24	Fire ball.

The cobœas interrupted the list of phloxes because desirable to place these rank-growing vines requiring a trellis, at one corner.

The phloxes failed in no instance to make a good stand, bloomed freely, and in general were probably true to the varietal names. Upon September 20th the following notes were made :

It is observed that as the plants get older there is tendency to vary from the normal form. The most conspicuous variation was the green (chlorotic) form, met with in nearly every row. These plants have the flower clusters with the bracts much prolonged and oval-shaped ; the corollas are with long tubes and the lobes not fully expanded, giving a half-opened appearance to the bloom.

A study of these greenish clusters show that many of them carry a small amount of the color, characteristic of the variety. Among the white sorts the green flowers are present, usually a whole plant being chlorotic when any part has green flowers. With red flowers, for example, the "green" plants bear flowers that are with the red only along the mid-rib of the corolla lobe ; that is, a single stripe. When there are flowers in a cluster, usually there are no two alike.

Aside from the tendency to produce green flowers, there was a variation seen in several plants. The usual change was shown in a loss of the normal color in one or more blooms, while others in the same cluster showed a deeper color than the ordinary. This was as if the color in the whole cluster had been unevenly distributed, and where one lacked another had an excess. Such clusters were marked especially for saving seed.

The phlox are particular favorites of certain butterflies, and among these insects the Papillios are the favorite attendants. The long tube of the corolla excludes all the smaller insects and those with short probosces.

The profusion of bloom upon these plants has been something

astonishing, especially in view of the fact that no cuttings have been made, and seed was found all through the season. The constant supply of blooms in great variety of colors, varying through all shades from white to a dark red, the *Phlox Drummondii* must be accredited with a high rank. These plants could scarcely fail to give satisfaction when making a bed of solid color or as mixed or in ribbons, as taste or circumstances may dictate.

The star form (*cuspidata*) was grown in limited amount for purposes of crossing, and it proved wonderfully variable, for out of a dozen plants no two were alike in size, shape and color of the blooms. It is sufficiently peculiar as to merit a place in the breeding grounds, but the colors need fixing, and much may be done to improve this strain of phlox.

Half Plot III.—Various Polemoniaceæ.

In this area three genera of closely-related plants were brought together for purposes of study and breeding. The following is the arrangement of the species, the rows running across the belts as with the annuals given above:

Belt 4.	Belt 5.	Belt 6.
Gilia tricolor.	Gilia capitata (blue).	Gilia nivalis.
Gilia achillæfolia alba.	Gilia achillæfolia rosea.	Gilia laciniata.
Phlox subulata var alba.	Phlox maculata.	Gilia achillæfolia.
Phlox pilosa.	Phlox paniculata.	Polemonium grandiflorum.
Phlox divaricata.	Phlox Himalayense.	Polemonium cæruleumalbum.
Phlox subulata var frondosa.	Polemonium cæruleum.	Polemonium reptans.

As these are set for continuous tests in crossing, little need be said upon the group for the first season. The polemoniums are early bloomers, while the phloxes and gilias, especially some of the latter, are continuously in flower from early summer until the season closes.

EXPERIMENTS WITH SPRAYING.

The spraying with fungicides this season has been limited almost entirely to soda-bordeaux, with the same formula as in previous years, and it was used only upon a small portion of the crops grown.

Tomatoes.—The middle belt of "stock" tomatoes, Plot III., Series III., received four applications of soda-bordeaux on the following dates: July 20th, 29th; August 8th and 27th.

The blight (*Septoria Lycopersici* Speg.) was the only form of

disease observed this season, and as the plants were but lightly infested there was but little difference observed in favor of the sprayed belt.

Among the crossed tomatoes the leaf spot developed to a much greater extent, many plants being nearly defoliated before the end of the season. There was almost no fruit rot the present season.

Chard.—Belt 5 (2 rows), Plot IV., Series V., was sprayed four times with soda-bordeaux upon the following dates: July 20th, 29th; August 8th and 27th. Considerable leaf spot (*Cercospora beticola* Sacc.) had developed upon the sprayed rows by August 27th, but to a much less extent than upon the unsprayed. The foliage of all was badly cut up by hail early in July.

The tops of all plants were removed about September 1st, and the subsequent growth suffered much less from blight.

Æsculus.—Several three year-old horse-chestnut trees, alternating with untreated ones, were sprayed with soda-bordeaux on June 17th, 15th; July 29th; August 8th and 27th. The contrast between the unsprayed and sprayed plants was very decided, the former being more or less defoliated before the end of the season. Like results were obtained in 1900.

Grapes.—The middle third of the arbor at the farm-house received five applications upon the following dates: June 8th, 17th, 28th; July 15th and 29th. Ordinary bordeaux was used for the first spraying, soda-bordeaux for the remainder. The mildew was practically absent from the entire arbor. The sprayed foliage was seriously burned by the fungicide.

Kerosene Emulsion.

One belt of cucumbers and one of chard were sprayed three times with kerosene emulsion of half the standard strength—that is one ounce of ivory soap, two pints of kerosene to eight gallons of water. There was no checking of the blights and the plants remained unharmed by the emulsion.

One-third of the verbenas in the ornamental grounds were sprayed with the same emulsion for the mildew upon August 1st, 8th and 27th. The conditions were highly favorable for the fungus during the first half of the month, and mildewed leaves were numerous at the beginning of the experiment. After two sprayings the treated plants were less affected than elsewhere and had a glossy appearance, apparently due to the emulsion. From the latter part of August to

the end of the season the mildew developed but little upon any of the plants.

One side of a lilac bush was treated with the emulsion August 25th and September 10th, without seeming to check the development of the mildew. In this case the mildew was well developed upon the foliage, and the two applications did not materially change the appearance of the leaves.

Three places in a large piazza plant of Matrimony vine were sprayed twice each week with the emulsion, and it seemed to prevent the appearance of the mildew upon the younger leaves; and the fungous patches upon the old ones were darkened and ceased to form spores.

Soda-Bordeaux and Paris Green.

To determine whether Paris green may be safely used with soda-bordeaux, the combination was applied to the following plants: Potatoes, eggplants, squashes, cucumbers and beans.

Each of the above were treated three times, at intervals of ten days and without harmful results, although the Paris green was used at the rate of one pound to 100 gallons, a much higher percentage than is commonly employed.

THE ASPARAGUS RUST.

During the present season it was not convenient to carry on any experiments with the asparagus rust, and only observations in the field and reports from the various Experiment Stations throughout the United States are given. The rapidity with which this disease has spread has added to the importance of a record of its present range.

Without reproducing the replies to the letter of inquiry sent out in September, the following extracts will show something of the wide range of the rust and also some points as to its relative abundance with that of last year.

From New England, where the asparagus is widespread, but generally grown only in limited quantities, the reports show that there is less rust this season. For example, in Professor Jones' report for Vermont, it is stated that "there has been less of the asparagus rust in this State than there was two years or so ago."

For Massachusetts, Professor Stone writes: "The rust has been prominent here this season and there has been a slight tendency for

it to spread. * * * My theory has been that drouth causes the plants to become weakened, and hence followed by an outbreak of the rust."

From Delaware, Professor Chester sends the following: "During the past two years it has not been as general and destructive as in the two preceding years, but all in all it is general throughout the State."

Professor Norton reports from Maryland that in some places the rust is abundant.

Professor Buckhout writes from Pennsylvania that "the asparagus rust is scarce this year—much less than before." From the South Atlantic States the replies are to the effect that the rust is not in evidence, but from Texas, Professor Price writes, "I have found the rust in Texas for the first time this year. * * * The first part of the season here was normal and the latter very dry, and the disease is still spreading. Judging from its first appearance here this year it seems quite likely that it will prove serious in the State."

For the Middle States the reports are favorable. Professor Selby, for Ohio, writes that "there appears to be no spreading of the rust." From Michigan, Professor Wheeler sends word that "the rust, so far as I can learn, is not on the increase." Professor Goff writes from Wisconsin that "a single case of asparagus rust has been reported to me this season. * * * This is the first * * * to my knowledge of the disease in our State." From Indiana, Professor Arthur reports the rust as abundant as last season, and "that the infection of this region in general came this year largely or wholly from spores blown from considerable distances."

Professor Burrell reports for Illinois that "the disease has been spreading, and is now known in at least a dozen plantations throughout the State. * * * This last year seems to have been a bad one for the development of the parasite. Some beds that were known to be infected have apparently not shown it at all or to a very slight extent. I am inclined to think that the very dry weather throughout July and August had something to do with this state of things."

From Iowa, Professor Pammel writes that "I think the rust is on the increase; at least in this vicinity, but I have not been in correspondence * * * with reference to its general distribution in the *State.*"

In Nebraska, Mr. John Sheldon has made a special study of the rust, and through Professor Bessey, of the Experiment Station, he reports as follows: "From observations made near Lincoln and the reports that have come in, there seems to be much less asparagus rust

than last year at this time. Much of the brush that grew in the early part of the season was badly rusted, but the continued dry and hot weather of the summer helped to check it on a few small patches that showed rust now. A few Æcidia showed on them early in the season, but not in sufficient number to bring about general infection."

To the northward in South Dakota, Professor Saunders reports: "I cannot find as it is spreading. * * * It was observed lately infecting a field near Yankton." In North Dakota, from Professor Bolley, it is learned that "the disease * * * did not make much headway upon the garden plot of asparagus until this last summer, when the attack was general and very destructive. The crop began to yellow early in August, and by the last week in August, when it should have been very green, it was strictly brown and dried up. * * * This season has been simply a good growing one, with a little excess of rain in the early part of July."

In matter of range, record is made of the rust having been observed in Wisconsin, and that it is now as far southwest as Texas, where it seems to be in a violent form. From the notes upon the rainfall in various States for the present year, it is not clear that there is a close relation between the weather and the amount of rust. It is likely only one of the controlling factors.

In our own State it is gathered from personal observation, conversation with asparagus growers visiting the Station and letters from other accurate observers, that the rust has not been as severe as last year. Why there is a decrease may not be easy to determine. The present season has been noted for its moisture and high temperature in summer. For example, the rainfall for the three summer months for this year were: June, 3.54; July, 5.87; August, 9.43, or a total of 18.84 inches (see table elsewhere), while last year the same months gave 3.08, 4.74 and 2.68 inches, respectively, or a total of 10.50 inches. It is seen that the summer rainfall this season was nearly double that of 1900. To show that the precipitation has been excessive, it is stated that the average rainfall for June, July and August for the last twelve years, including the present excessive one, is 13.56 inches. It is only suggested that in this increased amount of moisture there may have been a condition favoring a greater growth of the asparagus and a consequent increased power over the enemy. It is also possible that the rains may have served to wash the spores from the smooth stems before they had time to gain a foothold.

Another point of climatic difference this season, that distinguishes it from others, is the excessive heat of July, which was 3.4 degrees

above that of the average of the past twelve years. As a rule, one month, as July or January, etc., varies but slightly from the others, and, therefore, a seemingly small increase or decrease in the total average temperature is a great deal, and marks the month in which it occurs as either hot or cold. How this increased heat may have affected the rust is not clear, but it possibly was advantageous to the asparagus plants, giving them greater vigor and consequent resistant power.

Again, it may be that the considerable decrease of the rust may have been due to the effect of the natural enemies, the darluca in particular, which has been working unknown to the aspargus growers generally, and its presence is a hopeful sign here among fungi, as with injurious insects when some other insect is its parasite.

Another reason for the decrease may be the introduction of the French stock and the larger acreage of the "Palmetto," both of which sorts are far less susceptible to the rust than the varieties that ten years ago were the standard sorts.

The record for the year is encouraging, for, while it shows that the range of the enemy is no less widespread, there are indications of its destructiveness being abated. If much of the decrease of the past season has been due to the peculiarities of the season, as further observations may establish, it would be important information upon the case in hand.

Asparagus Rust on the College Farm.

On October 18th an inspection was made of the four plots of asparagus, row by row, and not plant by plant, as formerly. The whole field showed much green, and was in a far superior condition to that of last year, and better than in 1897, when the first observations and records were made for this field. The first evident thing was the comparative absence of the rust from the "Palmetto" variety, and the three rows of this sort in each plot were easily selected from the others, because of the deep green color and a large size of the plants.

One other sort, "Argenteuil," of which there is but a single row, showed equal exemption, but this is of younger plants than the "Palmetto" and much smaller.

In order to make a more definite record, percentages are assigned to the amount of rust, as in former years. Upon the same basis as for other years, the "Palmetto" does not show more than 20 per cent. of the rust, and the same is true of the "Argenteuil." There

seemed to be no observed difference among the other varieties, namely, "Mammoth," "Elmira," "Columbian," "Colossal," "Brunswick" and "Cross Bred," and for these the record is 50 per cent. of rustiness.

The same area gave 77 per cent. last year.

It was observed that the rust was much more abundant upon the west than on the east side of the plants, and it is suggested that the dew dried off quicker on the side toward the morning than the afternoon sun, and then the spores did not have as good an opportunity to infect the plants as upon the west side, when the moisture remained longer.

EXPERIMENTS WITH PEAR BLIGHT.

Owing to the change of management of the pear orchard, in which the experiments with pear blight were being carried on, the work is, of necessity, brought to a close, and here is given the results of the four preceding years.

The plan of the experiments is given below :

	CULTIVATED ROWS.			Unchanged.	SODDED ROWS.		
	Barnyard manure.	Nothing.	Commerc'l fertilizers.		Barnyard manure.	Nothing.	Commerc'l fertilizers.
Row 1 { Winter (January) Pruning. }	1	2	3	4	5	6	7
Row 2 { Winter and Summer (January and July) Pruning. }	8	9	10	11	12	13	14
Row 3 { Summer (July) Pruning. }	15	16	17	18	19	20	21
Row 4—Check	22	23	24	25	26	27	28
Row 5 { Winter (January) Pruning. }	29	30	31	32	33	34	35
Row 6 { Winter and Summer (January and July) Pruning. }	36	37	38	39	40	41	42
Row 7 { Summer (July) Pruning. }	43	44	45	46	47	48	49

Fig. 2.

Plan of the Pear Orchard Experiment ; the numbers represent the trees.

The results for the first year were given in detail upon pages 378–383 of the Report for 1897. The blight had been severe over the whole Keiffer orchard, then twelve years from setting, and from it the block of 49 trees was selected for its uniformity in size of trees and amount of the disease.

It will be seen from the above scheme that in the rows running in one direction (up and down) all the trees in a given row receive the same soil treatment, while in the rows running at right angles to these the trees are pruned alike. Three rows are kept in sod and three rows under cultivation. The row lying between these two belts of three each was treated the same as the other portions of the orchard, which surrounded the experiment block upon all sides.

One row each of the sod (row 1) and the cultivated belts (row 5) received barnyard manure in duplicate amounts, namely, five tons per acre of a mixture of horse and cow manure well rotted. Two other rows (rows 3 and 7), similarly situated, received commercial fertilizer, consisting of equal parts of ground bone, acid phosphate and muriate of potash, and at the rate of 900 pounds per acre. Rows 2 and 6 received no manure or fertilizer and separated each of the above pairs of rows.

The orchard had been under cultivation, and the ground preparation consisted in seeding down, upon the 15th day of October, 1896, the land under the right-hand three rows of trees. A mixture of timothy and clover was used; the catch was fine and a rank growth covered the ground by the next July.

In the pruning experiments the rows were taken at right angles to the soil treatment above described, and consisted in only two points of difference, namely, in the times of the removal of the blighted twigs. The trees of the upper row were pruned only in January of each year; in the row next below, in both January and July, and in the third row only in July. The middle row of the seven received no pruning, and rows 5, 6 and 7 were a duplicate of rows 1, 2 and 3, respectively.

The first pruning was in January, 1897, and, following a season of unusual blight, was very severe—so much so that more than half of the tops of some of the trees were removed, many of the large limbs being entirely removed. Any branch showing the dead tips and blighted patches were cut below the latter.

In the July pruning only twigs showing the dead, leafless tips of last year's destruction, and the dead twigs with their blighted leaves attached and that had been killed the present season, were removed.

In the summer pruning the trees were not cut nearly so severely as in the winter, because the green foliage served as a guide, and not the blighted patches upon the branches. The average length of the summer prunings was not far from three feet, while that of the winter was perhaps three times as long.

The following table shows the amount of pruning each tree received in terms of branches for the four years :

79	16	10	14	29	12	13
27 Died.	33	43	9 Died.	62	10 Died.	56
44	25	85	82	58	116	18
....	....	....	Died.	....	....	Died.
4	4	....	18	7	1	....
5	6	17	25	34	54	98
11	32	84	89	.... Died.	143 Died.	89

Seven of the trees died during the four years and their places were reset with young specimens of the same variety.

The following table shows the total crop, tree by tree, for the four years, in terms, of haskets holding five-eighths of a bushel.

								Total.
1........	46	41	24.5	15	26	14.5	25	197
2........	5	42.5	35.5	00	29.5	34	28.5	175
3........	47.5	39	31	37.5	38.25	40	31.5	264.75
4........	35	52	37.5	27.25	39.50	40.5	16.26	288.50
5........	42	45.5	37	32	33.75	32	33.5	255.75
6........	33	30	36	44	34	47.5	35.25	256.75
7........	50	42.25	38.5	39.5	00	31	40.5	241.75
Totals........	258.5	292.25	240	195.25	201	244.5	200 5	

On account of the death of certain trees, seven in all, and a large percentage, it is difficult to derive any results from the four years of the test—a period all too short for experiments of this kind.

If the fruit from all trees that died during the four years is omitted, the average for each row is by years as follows :

	1897.	1898.	1899.	1900.	Average.
Row 1..................	4.9	2.64	10.5	10.1	7.04
" 2..................	4.8	3.30	15.4	12 2	8.92
" 3..................	5.0	6.03	15.9	10.7	9.47
" 4..................	4 4	6.00	14.7	14 0	9.77
" 5..................	4.8	5.25	15.1	12.0	9.29
" 6..................	3.8	4.60	14.7	14 0	9 27
" 7..................	4.9	5.54	18 5	13.6	10.63

Much of the largest yield was during the last two years. The averages do not show any remarkable variations in yield, excepting that row 1 is quite low and row 7 considerably above the others, the middle five being very near the same figure. The unpruned row (No. 4) was better than the average of the treated trees.

The following table is of the averages for the rows with soil treatment in common :

	Row 1.	Row 2.	Row 3.	Row 4.	Row 5.	Row 6.	Row 7.
1897..........	5.43	5.18	2.93	3.50	5.17	4.64	4.54
1898..........	5.83	5.57	4.93	4.37	4.50	4.35	4.18
1899..........	17.60	18.00	13.70	13.00	13.80	16.30	13.30
1900..........	13.70	14.40	10.90	13.60	10.00	11.60	11.50
Average...	10.64	10.79	8.11	8.62	8 37	9 22	8.38

If the conclusion is to be drawn from the yield of crop, the averages show nothing striking for either the sod treatment or the cultivation of the soil. It is to be noted that the best yield in the cultivated area was unmanured, and the same is true for the portion in sod ; but the differences are so small that the individuality of the trees might account for the variation. With the cultivated land, barnyard manure gave better results than the commercial fertilizers, but in the sod land the two corresponding rows were the same. If anything is indicated, it is that the soil of this orchard was sufficiently rich for a full yield of Keiffer pears without additional fertilizing for at least the four years covered by the experiment.

ROOT PARASITES.

Early in the season Hon. E. T. Gill, of Burlington county, sent specimens of a weed that was found in considerable abundance in his clover field. It proved to be the clover broom-rape. This is a flowering plant that is closely related to the "Snap Dragon" of the garden, and the "Toad Flax," or "Butter and Eggs," a common weed of the fields. The plant in question has a strange habit of fastening upon the roots of the clover plant and robbing it. The broom-rape, in other words, is a parasite and shows its thieving method of getting its living by being devoid of the ordinary green so essential to plants that get their food out of the crude substance of the earth and air. The broom-rape consists, therefore, of a very limited root system, which is fastened to the roots of the clover, known as its host plant, from which a comparatively stout, pale, yellowish-brown stem arises for a foot to twenty inches, bearing numerous sharp-pointed brown scales for leaves, of no great service to the plant, and a spike of blossoms that are of good size, and in color a mixture of yellow and blue.

The photo-engraving (Plate VIII.) gives three of the broom-rape plants from which the earth has been washed, and showing the peculiar method of attachment to the clover roots. The one in the middle is the largest of the many sent by Mr. Gill, and shows how, by being attached to one of the side roots of the clover, the parasite may gain enough nourishment to make a large stem, shaped like an ox-whip, with the large end attached to the host and bearing numerous flowers throughout the whole length of the portion extending above ground. Clover that is thus attacked cannot make a satisfactory growth, and from the subterranean nature of the pest during its early growth, any remedy is not easily applied.

In the present case it seems as if the seed of the broom-rape came into the soil along with that of the clover, but as all of the supply of seed had been sown, there was no opportunity upon the part of the Experiment Station to make an examination. The seed of this broom-rape (*Orobanche minor* J. E. S.), as with all the others, is very small and could pass as "dust" with the clover seed, and therefore is neither easily detected nor knowingly removed. If one was suspicious of the presence of this enemy, the clover seed might be especially cleaned, aud even soaked in water, to remove the small

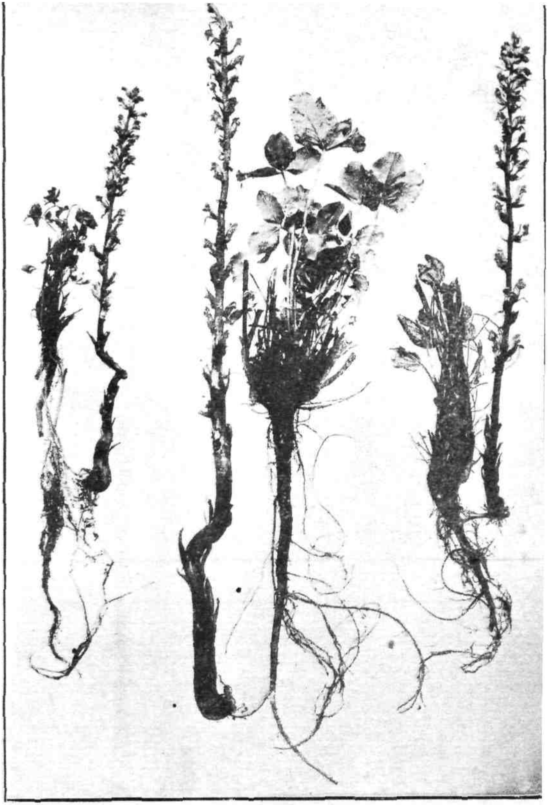
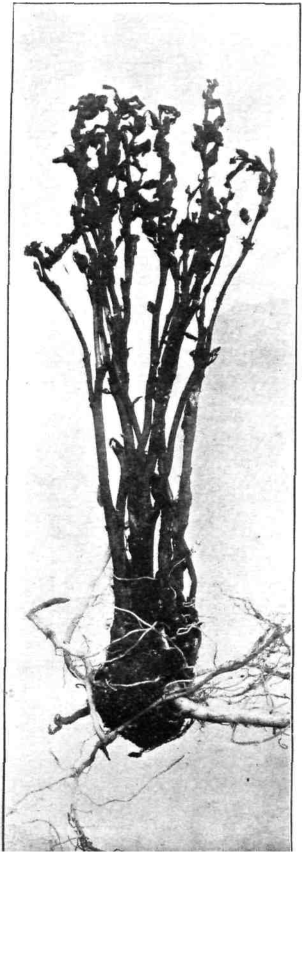


PLATE VIII.

Three broom-rape plants upon red clover roots.



When the weed is found in the field it should be dug up and destroyed, and of course no clover seed saved from the infested area.

Fortunately, in this country, this parasite has not become generally troublesome, but in Europe, from which it came to us, it is more common.

H. Garman,* in his illustrated bulletin upon this subject, states that this plant has been in Kentucky for at least ten years. The parasite injures hemp and tobacco, in some cases to the extent of 50 per cent. of the crop. One observer states that he has seen it upon tomato. "Rotation of crops, burning over infested fields, care in collecting seeds for planting and the use of fertilizers to stimulate growth of crops," are suggested as methods of prevention of injury. "Gas-lime applied to the land in the fall has been found useful in destroying the broom-rape seeds."

In the Kentucky Station Report, 1896, Professor Garman states that the broom-rape was found upon the roots of cabbage, rape and shepherd's purse; but all attempts to cause it to establish itself on watermelon, clover, wheat and potatoes have failed.

Broom-Rape Upon Tomato.

During the past season a single tomato plant in the Experiment Grounds was infested with a broom-rape. This is a different species from that above considered, upon the clover, but of the same genus Orobanche, and is called *Orobanche ramosa* L., because of its habit of branching. The parasite fastened itself upon one of the several roots of the tomato plant and produced a base of cousiderable size below ground, from which a cluster of branching stems arose, bearing the many bluish-yellow flowers above ground in early July. The photo-engraving (Plate VIII.) shows the parasite after the soil had been carefully washed away; but the flowers had become withered before the picture was secured. The similarities between the parasite of the tomato and the clover may be seen from the plate, the chief apparent difference being in the one having a single stalk and the other a cluster compacted at the base.

It is interesting to note that the branched broom-rape is a common parasite upon the roots of hemp and tobacco, in Kentucky, where it is often a serious pest. The tomato belongs to the same family with the tobacco, and therefore, as these parasites go, it might be expected upon such nearly-related plants.

* Bulletin 24, Kentucky Experiment Station, 1890.

Like the clover pest, this one is from Europe, where it is destructive, and tobacco and hemp culture is sometimes suspended for a time upon badly-infested areas, that the soil may become cleared of this root parasite.

ERGOT UPON GRASS.

Mr. A. M. Newman, Delaware, Warren county, made complaint, early in the season, of a growth upon the grass of a low meadow, which, upon the examination of specimens, proved to be an ergot. The grass in question is known as "Reed Canary Grass" (*Phalaris Arundinacea* L.), which produces a rank growth of fair herbage, surmounted by plumes six inches or more in length. In these heads the ergot appears as dark, hard masses, which look like enlarged grains, while in fact they are due to a fungus that takes possession of the grain when quite small, and, instead of an ordinary seed, a hard body is produced several times the size of the normal grain. See Plate IX.

A similar growth is met with upon the rye and many of the grains and grasses. When upon the rye it is often called "Spurred Rye," because of the hard grains, being, in size, shape and extreme hardness, somewhat like the spurs of a cock. These ergots are all peculiar in being very poisonous, and that upon the rye, when grown with the ordinary grains and eaten in bread, has often proved fatal to the human subject. This fungus growth produces a disease known as "ergotism," which is recognized by a loss of the use of the extremities. Thus, a person may lose a finger or a whole hand, by a sort of amputation, the circulation stopping and the part decaying away, leaving the stump of finger, arm or leg. When live-stock eat the ergoted grass in excess, the animals suffer in the same way from ergotism. Whole herds have perished in the West from this cause, as have entire villages of people in Europe, the latter largely because of a lack of care in separating the diseased grains from the others.

It is well for farmers to be aware of the nature of the outgrowths that may occur upon the heads of grains and grasses, and take any precautions necessary to avoid ergotism.

As the disease is confined to the heads, it follows that live-stock run no risks in ordinary pasturage until the grasses go to seed.

It is a fact that the ergoted grasses are more apt to be in the low land than where the soil is dry, and it is from the wild grass along streams that the most trouble is apt to arise.

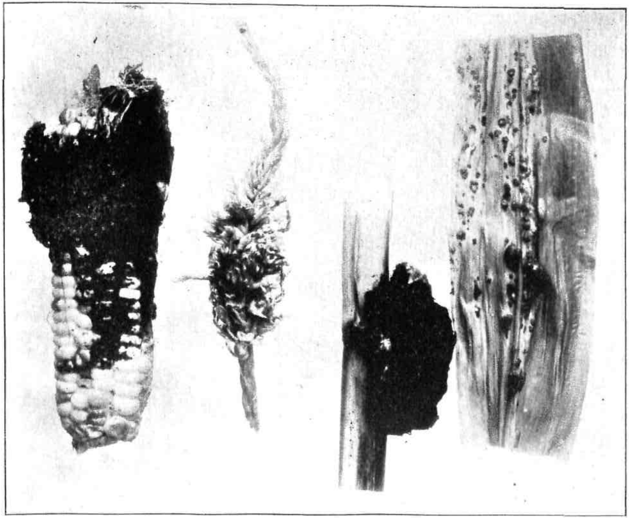


PLATE IX.

Upon the left, ergot upon the heads of reed canary grass, showing separated ergotted grains. Upon the right, cornsmut upon sweet corn ear, tassel, stalk and leaf, respectively.

NOTES UPON CORN SMUT.

The smut of corn was more than usually abundant the present season, and particularly so upon the early crop. In whole fields it was sometimes difficult to find a single tassel that did not show the smut, and often so badly that the whole top of the plant drooped because of the extra weight due to the smutted tassel. Soon after, the smut followed in the ear, and as the group of leaves out of which the ear grew was smutted, it seemed likely that the infection of the ear was from the tassel above.

The engraving (Plate IX.) shows an ear of sweet corn badly smutted at *a*, an infested tassel at *b*, a mature stage of the smut upon the stock at the joint at *c*, and the form often met with this year upon the foliage is shown at *d*.

THE BLIGHT OF CUCUMBERS.

There has been much complaint of blight upon melons, particularly the cantaloupes. An examination of the fields shows that the plants were in apparent good health until the middle of August, when the fruits were nearly full size. At that time the foliage became first spotted with yellow, soon turned brown and coiled up, leaving the fruit without any foliage to furnish them the sustenance desired, and they consequently became shriveled and worthless.

A microscopic examination of the leaves showed that the trouble was primarily due to the cucumber mildew (*Plasmopara Cubensis* B. & C.), which was favored in its growth and fatal developments by the conditions of the weather.

This mildew may be determined in a general way by the characters named above—that is, the yellow spots upon the upper surface of the leaf, followed by the brown color and coloring of the foliage.

There are other diseases of the melon tribe of plants, but none that behaves in this way. That there is a remedy at hand is beyond question, but the disease is so rapid in its growth that it needs to be used before any signs of the trouble are manifest. For example, during the present season a plot of cucumbers has been kept in full leaf and vigorous growth, upon the Experiment Area, by the use of soda-bordeaux, while a field of untreated muskmelons, not far away and no more susceptible, was entirely ruined by the first of September.

Several Experiment Stations have been seeking for remedies for the melon and cucumber mildew, and all find a satisfactory one in

the spraying, provided it is done early, in anticipation of the enemy, that may come with great force when the conditions of warmth and moisture prevail.

THE MILDEW OF THE GRAPE.

Last year (1900) the mildew was very abundant upon the grapevine at the time that the plants were in bloom. Photographs were taken of canes, flower clusters and leaves, showing the mildew in great abundance. (See last Report, Plate X.) This year the same vines were watched closely and were sprayed with fungicide, in an attempt to check the growth of the mildew. But no mildew appeared upon the young clusters, canes or foliage until about the first of September, when the appearance of the young canes and leaves corresponded well with the same parts in the springtime of last year. No mildew was met with upon the clusters, which, at that time, were maturing the fruit.

It is remarkable that the results of the two years should be so different. This leads to a study of the conditions surrounding the plants for the two seasons. It is seen that the rainfall was somewhat unusual for the period under consideration, there being nearly nine and a half inches (9.43) for August to 4.23 for same month of the previous year. This does not, however, explain the non-appearance of the mildew in the spring, when the rainfall did not differ much for the two spring seasons.

TULIP MOULD.

A grower of Cape May county made complaint that his tulips were diseased, and, upon request, sent specimens for examination. The trouble was diagnosed as the Tulip Mould, which is due to a fungus, *Botrytis parasitica* Cav. Upon this subject Massee* states that "Cultivated tulips are often killed by a mould, which forms olive-brown, minutely, velvety patches on the stem, leaves and flowers. At a later stage, smooth, lentil-shaped sclerotia, at first grey, then black, appear, mostly in the outer parts of the bulb, sometimes being so numerous as to form black crusts. Preventive means: When the mould is observed the plant should be taken up and burned, to prevent the formation of the sclerotia, some of which are often

* Plant Diseases, p. 158.

formed in the soil, close to the bulb, and thus endanger subsequent crops." The trouble is figured by Cavara*.

The botrytis in question is closely related to several others, and particularly the one causing a serious disease among lilies, investigated by Dr. Marshall Ward†, in England, and by Mr. S. S. Kean, whose results were published, with colored plate, in the "Botanical Gazette" for January, 1890. "Professor Ward calls the lily disease one of the most annoying pests that the horticulturist has had to trouble him of late. The disease first shows itself as small, rusty spots upon the buds and leaves, and, by their enlarging in the blossoms, are ruined. This botrytis consists of coarse threads, which run in all directions through the attacked branched stalks, bearing multitudes of spores."

This form of mould is common upon many plants, and at times is very destructive to root crops, as turnip and carrot. The onion, another bulbous plant, is often attacked by the same or a similar gray mould (Botrytis). The multitudes of spores borne upon the tips of the branches germinate quickly, and, when lying upon the surface of a little leaf, will bore their tubes through the epidermis. When once inside, the thread increases in size and grows rapidly in length, branching and causing decay as it pushes along. After the Botrytis fungus has grown for a while it may produce dark, hard bodies, by a peculiar twisting and knotting of its threads. These dark masses, or sclerotia, remain uninjured through the winter, and when spring comes they produce peculiar, trumpet-shaped outgrowths, which finally give rise to multitudes of spores. These are set free, and, finding their way to the young lily, produce the destructive gray mould again. These spores, by their large numbers and quick growth, show how it is possible for the lily disease to spread rapidly. The Botrytis is fond of moisture, and, in a dry season, the lilies may be great. Mr. Kean suggests, as a remedy, "the planting of some other crop in alternate rows, which, with high and spreading foliage, will prevent the collection of the dew upon the leaves and thus check the fungus, so dependent upon moisture for its propagation."

A similar mould (*Botrytis galanthina* Berk.) is upon the "snowdrop," a plant closely related to tulip and lily. As this produces dark masses of sclerotia, it, like the others, may be classed in the genus Sclerotinia, as *S. galanthina* Lud. and other similar cases, so soon as the fruiting form associated with the sclerotids is determined.

---

*In Ann. Pat. Veg. 10, Tab. VI., Figs. 1-4.

There is a form or species (*Sclerotina bulborum* Wak.) upon the onion. Others are upon the wind flower (*S. tuberosa* Fckl.), lettuce (*Botrytis vulgaris* Fr.), eggplant fruit (*B. fascicularis* Sacc.), and another is common upon carnation blooms.

The most common gray mould is *Botrytis cineria* Pers., associated with an ascoform, the *Sclerotinia Fuckeliana* DeBy. The former and older name was given to the more conspicuous stage of the fungus, which may be met with upon decaying vegetation quite generally. The second and "perfect form," as it is called, is less common, and, therefore, the confusion in the determination of a species, unless the perfect stage, is present with the mould form.

The tulip plants that were affected were set in the previous autumn, the bulbs being procured direct from Holland. The plants in the same bed where the mould appeared last year were the worst of all. Some specimens of *Lilium candidum*, growing near tulips, were apparently affected with the same trouble.

FUNGI AS RELATED TO WEATHER.

In temperature 1901 had a cold February, with a very hot July, that continued into August. There was an excess of rain in June and July, with an official record for August as follows: "The precipitation, the heaviest ever recorded during any August since the Service was established, came in the form of severe local thunderstorms. * * * The average (rainfall) for the month, 9.43 (inches), is 5.22 above the normal, and 6.75 above the average for the corresponding month of 1900."

The year has been one in which there has been very severe losses among the truck crops throughout the State; but perhaps nothing has suffered more than the muskmelon (citron, canteloupe). This crop has been ruined in some parts of the State, and this was largely due to the remarkable development and spread of a mildew (*Plasmopara cubensis* B. & C.)

This is a fungus quite closely related to the mildew of the grape, and in its need of moisture for its spread resembles the one causing the rot of potatoes. It is not unlikely that the unusual temperature and moisture at the time when the melons were growing most rapidly served to develop this enemy to the destruction of the forming fruits.

It is true that persons who lost their fields will have less chances of escaping the scourge next season, the conditions remaining the same,

because of the stock of the germs of the disease that have accumulated the present year.

It may be possible, as with potatoes, to grow the crop so early as to escape the mildew, which does not come until the vines are well advanced. Some growers were able, this season, to get a portion of the crop, and by extra efforts towards earliness something more may be gained.

The matter of asparagus rust is treated elsewhere, and, in passing, it may be said that this is a fungus that necessarily must make its attacks late, and it is probable that the conditions of late summer and autumn have not been as favorable for the rust as for the past two seasons. It seems to be a fact that the asparagus beds were in much better condition in October than formerly, some of them being quite green.

The following items are gathered from the "Crop Bulletin," issued by the State Weather Service during the growing season :

April and May—"Heavy rains," "Soil full of water," "Potatoes rotting," "Anxiety concerning extent of rot," "Lima beans and sweet corn rotted badly."

June 4th—"Frequent heavy showers," "Mnch seed has rotted in the ground." June 11th—"Cherries rotting on the trees," "Corn yellow." June 18th—"High temperature," "Plums and strawberries have blighted," "Potato crop poor." June 25th—"Cool nights," "Fruit drops badly," "Considerable red rust in wheat," "Oats rusting."

July 2d—"Rain greatly needed," "Much rust," "Oats badly affected with rust," "Cherry trees blighted and crop ruined." July 9th—"Intensely hot weather," "Frequent showers," "Oats blasting," "Potatoes injured." July 16th—"Cool, cloudy and very humid weather," "Wheat and rye sprouting in sheaves," "Early potatoes almost a failure." July 23d—"Showers almost daily," "Grain damaged from sprouting." "Apples, plums and peaches are still dropping from the trees," "Appearances of blight" (potatoes). July 31st—"Plums and grapes rotting."

August 6th—"Weather normal," "Tomatoes poor." August 13th—"Heavy rains," "Melons late," "Canteloupes * * * badly infested," "Tomatoes dropping off." August 20th—"Tomatoes set light," "Plums rotting," "Peaches forcing," "Canteloupes very poor." August 27th—"Warm, foggy weather," "Peaches, potatoes, tomatoes and grapes rotting."

The following table shows the temperature in degrees (F.) and rainfall in inches for the present year, and the average for the past twelve years.

	Temperature.		Rainfall.	
Month.	1901.	Average 12 years.	1901.	Average 12 years.
January	30.4	31.4	3.66	3.87
February	25.4	30.9	4.50	4.07
March	39.2	38.7	3.89	4.18
April	48.3	50.0	3.42	3.32
May	58.6	60.7	4.50	4.44
June	70.0	70.1	3.54	3.29
July	77.3	73.9	5.87	5.61
August	73.8	72.6	9.43	4.60
September	66.8	66.1	3.38	3.21
October	54.4	53.9	1.93	3.56
November	.....	.....	.....	.....
December	.....	.....	.....	.....

THE NEW GREENHOUSE.

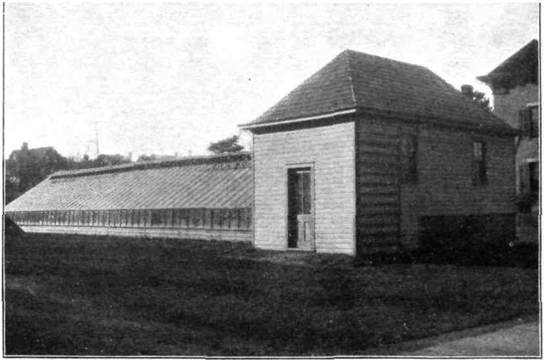
The Botanical Department is now provided with a plant-house, located near to the Experiment Station building, and therefore close to the laboratory and herbarium. It consists of a glass-house, 20 by 68 feet, and a head-house, 12 by 24 feet. The main entrance is level with the earth, and from the large vestibule the boiler-room is reached by a few steps. Above the heater and coal-bin is a general work-room.

From the vestibule the door leads directly into the plant-house, which is divided crosswise, near the middle, into two rooms, piped independently, so that the hot water may give different amounts of heat as required. The general appearance of the whole house may be obtained from the upper engraving in Plate X.

SEEDLESS TOMATOES.

Dr. E. L. Sturtevant, in his excellent paper upon "Seedless Fruits,"* mentions no less than sixty species of plants the fruits of which have been known to be seedless, either occasionally or as a regular thing, Under "Tomato" his statements are very brief, and omitting the table, are as follows: "It is a matter of common observation that the finest quality of tomato fruit contains fewer seeds than do those of inferior varieties. Burr also says there is a seedless

* "Memoirs of the Torrey Botanical Club," vol. I., No. 4, pp. 141-188, 1890.



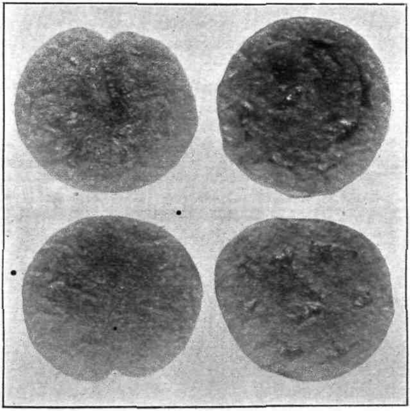


PLATE X.

Upper—Plant House of the Botanical Department (cut from True Bull. 93 U. S. Dept. of Agriculture).
Below—Seedless tomatoes in section as grown under glass.

variety, smooth and handsome, with few seeds." It is found that Burr, above referred to, in his book,* now approaching old age, but full of valuable information, adds but little to Dr. Sturtevant's statement when it says, under "Seedless Tomato," "Very similar to, if not identical with, 'Perfected Fruit,' almost rose-red, solid and with comparatively few seeds." The "Perfected," including the so-called "Seedless," it is stated, is an "improved sub-variety obtained from the Common Large Red by cultivation and selection." To further quote: "From the time of the introduction of the tomato into general use in this country, the Large Red was almost the only kind cultivated or even commonly known."

These notes show that what was called the "Seedless Tomato" was only so in name; that it came upon the horticultural horizon before the development of the "Trophy" and its class, and it was a cultural form of the old, original red tomato, and is now lost from sight. A second fact of special value is Dr. Sturtevant's opinion as to the comparatively high quality of seedless tomatoes and the quickly-following inference that the reduction of the seeds would be at the gain of value to the fruit.

With this as an introductory, it may be of interest to state that absolutely seedless tomatoes have been produced at the New Jersey Experiment Station, and the following is a record of how the desired and possibly quite novel fruit was obtained:

In the breeding of tomatoes, that has been going on for some years, only two varieties have been employed, namely, the "Dwarf Champion," representing the stiff-stemmed, upright type, sometimes called the "Tree" tomatoes, and the "Golden Sunrise," which is a low-spreading, large, rapid-growing variety, practically the opposite of the first mentioned. The "Champion" bears a medium-sized, red fruit, and the "Sunrise" has a large, golden-yellow berry. These two sorts prove to be sufficiently distinct for the breaking up of their types when brought together in the process of crossing. As a result, there are many offsprings, that combine closely some of the characteristics of the parents, while others are left unchanged. This is observed in the stems and foliage, and perhaps more noticeably in the fruit, which may be mottled with the red and yellow. One of the ends sought, and being reached, is a fruit with a blush like a "Crawford" peach, at the same time being of high quality and borne by vigorous and prolific plants.

* "The Field and Garden Vegetables of America," Fearing Burr, Jr., 1865.

Last year there were two plants (Nos. 67, 177) which showed a most remarkable vigor, overreaching the ordinary plants from the same mother fruit surrounding them. These "Giants," as they were called, both resulted from crosses of "Champion" upon "Sunrise," and their fruits were red, like the pollen-plant, while in vigor of vine they exceeded that of the seed parent. Number 67 produced eighty-three fruits, all of them uniformly of small size, averaging an inch and a quarter in diameter, with the seed cavities, four to six in number, filled with a pulp but bearing only a few seeds—a half dozen or less.

The second very exceptional plant (No. 177), the greatest in size of all, bore only twenty fruits, red, like those of No. 67, but somewhat smaller and with the seed almost entirely absent from them all. In these the seed cavities were nearly obliterated, and the fruit became a nearly even mass of flesh, firm in texture and of snperior quality.

Toward the close of the season the stems of hoth the above plants were layered, and cuttings were also taken, and therehy many plants were obtained that, taken into the greenhouse, bloomed and fruited during the winter. Several of these fruits were entirely solid, and any provision for seed production had disappeared. Fruits of this character are shown in the lower half of Plate X.

There is still much to be done to increase the size of the fruits, which, if accomplished by breeding with normal plants, may neutralize all that has been gained in the way of seedless fruits. The aim is to reduce the seed production to a minimum and not overcome it entirely; in short, to have a fruit of good size, with a rich, solid flesh, in which may be only enough of seeds to preserve the present way of propagation instead of requiring the gardener and trucker to resort to non-seed methods, as is necessary with the modern pineapple, banana, navel orange and the still later seedless lemon.

It may not be foreign to the subject in hand to state that the seedlings from these giant plants proved to be a very variable lot, with no two alike. Some were malformed dwarfs, that produced but a a single cotyledon, no plumule, and failed to grow, while others were misshapen in stem and leaf. Some were of the "Champion" type, others resembled the "Sunrise." Between the lines, the student of the problems of evolution may read some things that, while not conclusive, are certainly suggestive. The red and yellow types,

of the crosses from the track and upset the ordinary prolific methods of propagation by seed. Out of the wreck—to continue the figure—it is hoped to rescue by careful combination a form that, in time, may be able to maintain itself with profit to mankind.*

A STUDY OF DIMORPHISM IN BUCKWHEAT.

Buckwheat is one of the cultivated plants that has its flowers dimorphic—that is, with two lengths to the stamens and two to the pistils. One plant, for example, has the pistil with long styles and short stamens, and another with the three styles of the pistil short and the stamens long. The plan in this is for the insect visitants to carry the pollen of the long stamens of one flower and deposit it upon the tips of the long styles of another flower, and the pollen of short stamens to the stigmas of short-styled pistils. This is done without any plan or intention on the part of the insect, for a certain portion of its body will come against the long stamen and the long style, while another portion touches the shorter stamen and the corresponding pistil. This dimorphic type of blossom is generally understood to be for the purpose of wide fertilization—that is, the impregnation of one germ-cell with the male-cell produced by another flower.

Assuming this view of the case, the point of the experiment was to determine whether any condition of growth or previous parentage had any influence in determining the particular form that the flowers of any individual plant assumed.

Seeds for the greenhouse experiments were saved from long-styled and from short-styled plants, selected from a plot grown in the field the previous summer. The first sowing was made in boxes one by two feet square and six inches deep, on October 24th, according to the following schedule:

Box I. Seed from long-styled plants, sown in poor soil.

Box II. Seed from short-styled plants, sown in poor soil.

Box III. Seed from long-styled plants, sown in medium soil.

Box IV. Seed from short-styled plants, sown in medium soil.

Box V. Seed mixed, but from plants grown upon heavily-manured soil.

Box VI. Seed mixed, but from plants grown upon poor soil.

*A paper upon this general subject of "Experiments with Tomatoes," given by the writer before the Denver meeting of the Society for the Promotion of Agricultural Science, in August, contained some of the above facts

The flowers were counted upon November 27th, with the following results:

	Long-styled.	Short-styled.
Box I	20	12
Box II	11	25
Box III	11	17
Box IV	22	20
Box V	25	18
Box VI	14	21
Totals	98	113

The short-styled form was more numerous as a whole, but less so in three boxes, namely, Nos. 1, 4 and 5. The first four boxes are comparable, and here it is seen that the two boxes with "long-styled seed" gave 31 long-styled plants and 29 short-styled plants, while the two boxes with "short-styled seed" produced 33 long-styled plants and 45 short-styled plants. In each instance the form of the flower in the mother plant was in excess of the other type.

The poor soil gave 31 long-styled and 37 short-styled plants, while the medium soil produced 33 long-styled or 37 short-styled plants, or there is no evidence in this case of any influence on the part of tbe soil.

Boxes 5 and 6 show that the long-styled plants are more numerous when the mother plant has grown upon very rich soil and much fewer when the mother plants were upon poor soil.

On February 1st a duplicate of the above set was counted, with the following results:

	Long-styled.	Short-styled.
Box I	9	16
Box II	12	11
Box III	12	10
Box IV	13	14
Box V	11	5
Box VI	11	8
Totals	68	64

Here the totals are nearly the same. The two boxes with "long-styled seed" gave 21 long-styled plants and 26 short-styled plants, while the two boxes with "short-styled seed" produced 25 long-styled plants and 25 short-styled plants. Here the form of the flower in the mother plant was not that of the majority in the offspring.

The poor soil gave 21 long-styled plants and 26 short-styled plants, while the medium soil produced 25 long-styled plants and 24 short-

styled plants. Again, there is no evidence of any soil influence upon dimorphism. Boxes 5 and 6 show an excess of long-styled plants, and greatest when the mother plant had grown upon very rich soil—a result that agrees with the duplicate hoxes in the first series.

On January 11th a duplicate of the previous two sets was made, so far as the seeds employed is concerned, but the soil used was the same in all boxes and was three-fourths clean sand to one-fourth of fine soil, and therefore the nourishment was scant. The plants were small, and the following is the result :

	Long-styled.	Short-styled.
Box I	11	23
Box II	11	11
Box III	20	20
Box IV	13	10
Box V	14	9
Box IV	17	11
Totals	86	84

The totals are nearly the same. The two boxes with "long-styled seed" gave 31 long-styled plants and 43 short-styled plants, while the two boxes with "short-styled seed" produced 25 long-styled plants and 21 short-styled plants. Here the form of the flower in the mother plant does not show any positive influence upon the offspring. Boxes 5 and 6 have a large excess of long-styled plants, the greatest being when the parent seed was grown upon poor soil.

By combining the three above sets the following results are obtained :

	Long-styled.			Short-styled.		
Box I	11	9	11 = 40	12	16	23 = 51
Box II	11	12	11 = 34	25	11	11 = 47
Box III	11	12	20 = 43	17	10	20 = 47
Box IV	22	13	13 = 48	20	14	10 = 44
Box V	20	11	14 = 45	18	5	9 = 32
Box VI	14	11	17 = 42	21	8	11 = 40
Totals	98	68	86 = 252	113	64	84 = 261

It is seen that the totals for the two forms are practically the same. The "long-styled seed" gave 83 long-styled and 98 short-styled plants, while the "short-styled seed" produced 82 long-styled and 91 short-styled plants—that is, both forms of mother plants produced an excess of the short-styled form.

With mixed seed—that is, without regard to form of parent—that

while the poor soil produced 25 long-styled and 29 short-styled plants. So far as these two tests go there is evidence that high manuring produces an excess of the long-styled, and poor soil an excess of the short-styled, form.

But plants from the same lots of mixed seed grown in sand gave quite different results—that is, the greatest excess of the long-styled form was from seed grown in ordinary soil and sown in nearly pure sand.

In the experiments in growing the third generation from the long-styled and short-styled seed, the results ran as follows:

	Long-styled.	Short-styled.
Long-styled seed	12	11
Short-styled seed	9	13

This indicates that there may be a tendency for the mother form to exert some control over the form in the offspring. If this is a fact it might be possible, by constant selection, to do away with one or the other form.

SPRAYING EXPERIMENTS IN GREENHOUSE.

Only a limited amount of spraying was done other than for the destruction of insect enemies. However, a test was made to check the powdery mildew upon some of the ornamental plants, in particular the phlox, verbena and roses. The broad-leaved plantain (*Plantago Rugellii*), grown in the greenhouse for another purpose, proved to be a fine subject for this work, first, because the plants are very susceptible to the mildew*, and secondly, the leaves are large, well disposed for treatment and quite lasting.

The sprayings were made with a small apparatus, that produced a fine mist, and the plants were treated once in ten days. Several substances were used, but, as florists object to any discoloration, clear liquids were chiefly employed.

One of the mixtures used is the kerosene emulsion, made according to the following formula: Kerosene, two pints; ivory soap, one ounce, and water, eight gallons.

Upon the pholx, verbena and plantain this soon began to show

* The species upon the phlox, verbena and plantain, growing close together, was probably *Erysiphe cichoracearum* D C., and of the roses, *Sphærotheca humuli* D. C., but as it did not fruit the determination is not made, and is not essential to the results.

PLATE XI.

Mildew Experiments. Upper—On the left, sprayed Phlox plant; on the right, unsprayed plant. Lower—On the left, sprayed plantain; on the right, unsprayed plants.

desired results, and as the winter progressed it was evident that the emulsion was able to hold the mildew almost completely in check. Plants that were not sprayed became in all instances badly mildewed and dwarfed, while the treated ones kept nearly free of the fungus and showed a satisfactory growth in all parts.

Plate XI. illustrates the work in spraying. In the upper left-hand portion is shown a sprayed phlox plant, and on the right, one of the same age, untreated. The left-hand box shows five sprayed plantain plants, with a similar untreated box at the right.

ALBINISM IN SWEET CORN.

Albinism is occasionally met with in animals, as white mice, white crows and white blackbirds. In plants it is often partial and rarely complete, for in plants it is physiologically different from in animals, as, in its completeness, it is suicidal. The Century Dictionary defines albinism in plants as "A condition of flowers or leaves in which they are white instead of having their ordinary colors, owing to a persistent deficiency of the usual coloring matter, to be distinguished from blanching or etiolation where the color returns on exposure to light." Jackson, in his recent "Glossary of Botanic Terms," states, "Albinism, a disease from absence of normal coloring." In corn, albinos are perhaps the least rare; and many recall seeing white seedlings in the field.

The specimens that have been under consideration were met with in sweet corn that resulted from a cross between the "Black Mexican" and "Egyptian" varieties, and in the progeny of the second year of experimentation. The 1900 crop was grown from pink grains that were all from a single ear of the "Egyptian." (See Report for 1900, pages 439–444.) The one-twentieth acre was so situated that it had no opportunity for pollination from any other corn, save a few stalks of the same variety, ninety yards away. It was an inbreeding in a mild way. All of the ears of corn upon the plot in question were practically alike, in being thoroughly mixed and nearly equally between the white and pink or purple grains. In the tests for vitality of this corn the albinos became a prominent factor, and, in round numbers, one seedling in ten has proved to be white.

The crossed corn has been tested in several ways, with the thought of determining whether the tendency to albinism is inherent in the grains, or may be developed during germination. First, it was determined that the position upon the cob had nothing to do with this

phenomenon. The much-compressed and misshapen butt-grains are no more apt to produce white plants than those from the middle of the row; *neither are the small tip grains so disposed.* Both extremities of the cob produce inferior grains, which quickly lag behind in the race of life, and are, for that reason, unfit for seed.

The grains were mutilated with the knife by cutting away a half, or less, of the endosperm just after they had become softened, or before in some instances; and while such grains germinated more quickly, probably due to the more ready access of water, they made *a less vigorous growth than uncut grains* and *showed no increased* percentage of albinos.

As the lack of green is evident from the first, there seemed little use of testing different media for germination; but tests have been made between blotting-paper in pure sand and in potting soil; but none of these exerted any apparent influence upon albinism.

The best-matured grains from well-developed ears were placed in contrast with small grains of less perfect ears, and here there was a marked difference, the poorly-formed, starved or immature grains being more apt to produce the albinos. In one such instance a small ear, but with the individual grains of fair size and good appearance, produced as high as fifteen albinos out of the one hundred grains taken consecutively from three of the rows.

The grains were germinated with various media, in a dark chamber, with the same results as previously determined in the light. The albinos were easily selected from the time they were two inches high, because of the same pale color as when grown in the light, which was easily distinguished from the straw-color of the seedlings, that in the light would have been green. In several instances, when the pan of seedlings from the dark chamber was brought into diffused light, the straw-yellow plants quickly became green, and, of course, the albinos did not change their color.

Other methods of torture have been indulged in, as that of adding uncongenial liquids to the seeds, either in sand, soil or the blotting-paper; but none of these have resulted in changing the percentage of the albinos.

Excess of temperature has been applied. Thus, soaked grains have been placed in water on the window-sill, over night, and the ice thawed out quickly, and the freezing repeated the next night, while a corresponding lot of grains from the same ear was placed in warm, moist soil, that offered the best conditions for growth. Here, again,

the distress did not force any of the seeds to develop into the albino form, or, at least, the percentage of white seedlings was not increased.

Aside from the color, there is very little difference between the albinos and the normals when grown in the dark. They all are very long between joints, and soon fall to the ground. In vigor of growth, and in all other respects excepting color, there seems to be no difference between the albinos and the normal plants. In the light it is not so easy to come to this conclusion, for a young corn-plant soon puts on its working green color and begins the process of synthesis; but, from a large number of observations, it may be said, in general, that up to the end of two weeks there is very little difference in the size of the white and green plants from the same ear. After that time the green plants rapidly take the lead, and the lagging albinos have ceased growing at the end of four weeks. These white plants offer an opportunity for the study of several problems in plant nutrition, in connection with the seed and its accumulated substance.

It would seem that the treatment of the seed during germination has no effect to produce albinos.

A test of thousands of grains of many kinds of corn have resulted in no albinos, excepting in one lot of 1,000 grains of a pop-corn, remarkable for its rapid germination and vigor when one true albino appeared.

Tests have been made with the yellow grains on white ears and the yellow grains of yellow ears of field corn, and the same way with pop-corn, but as yet the albino has not appeared among them.

The cause may lie in the crossing that had been produced in 1899, namely, between two very distinct varieties; one an eight-rowed, black sort, and the other a ten twelve-rowed, white variety. Ears were then produced having a goodly number of the dark-purple or pink grains. It was these colored grains that were selected for the planting from which the albinos have been obtained.

No albinos are found in tests of the parent stock of "Black Mexican" and "Egyptian."

A STUDY OF DODDERS.

During the past winter the new greenhouse offered an opportunity for a study of that group of pestiferous plants known as the dodders, several of which are particularly destructive to crops, as that upon the clover, flax and allied plants.

The seeds of the dodder are not far from the size of those of red clover, and might be mistaken for alfalfa seed or even that of timothy. To show the relative size of the seeds of different species of dodder and some of the commercial seeds among which the dodder is carried as foul stuff, the engraving (Plate XII.) has been prepared where the seeds are shown in groups alternating with groups of seeds of standard forage crops.

A study was made of the germination of the dodder seeds.

The dodder root is the first portion to leave the seed-coats in germination, is colorless, and, while variable with the species and size of seed, near a third of an inch in length. It is distinguished from the stem by its somewhat greater size, absence of the yellowish-green that comes in the seedling when growing in full sunlight, and in its lower portion is covered with short root-hairs. These hairs are scarcely more than in name, being only papillæ upon the surface, arising from the middle of each surface cell in the area for a short distance back from the tip. In some roots the hairs come down to the tip, there being no root-cap and the end consisting of several cells of nearly equal length. The root grows very little in length as the plant elongates, and when the stem is two inches long, the root, then a third of an inch in length, is fully grown. The tip of the root is practically the same in structure, whether growing in water, sand or rich soil, with light or darkness. The normal position of the germinating plantlet is, with its root-tip, only slightly buried in the soil and extending upward, forming a "loop" in the stem, just above the root, the seed-coats, with the large supply of endosperm, still in the soil. As the growth advances the "loop" increases in size, the end of the stem finally becoming separated from the seed-coats and being lifted up free in the air, still with a "loop" near the end. After about ten days the slender wire-like stem becomes straight and the active nutrition begins.

All this time the root end has remained comparatively unchanged, fastened by the root-hairs to the soil, from which it imbibes water. The short, stout hairs are particularly interesting in presenting a movement of the protoplasm, that can be readily seen with a one-sixth objective, the flow being along the inner wall of the papilla. Under similar circumstances, ordinary seeds, like those of clover, will produce a long, slender root, penetrating deeply into the earth, showing an evident cap at the end, upon which no root-hairs appear until some distance back from the cap, and then they form as slender threads that are very many times their diameter in length and of

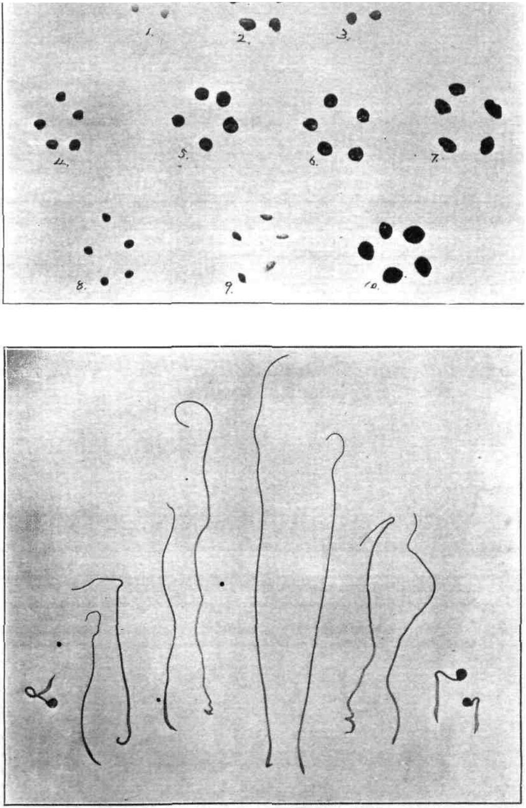


PLATE XII.

Upper—Seeds of six kinds of dodders, Nos 1, 3, 5, 6, 8 and 10, and of red clover (No. 2), Alfalfa (No. 4), alsike (No. 7), and timothy (No. 9). Lower—Seedlings of dodder from 4 to 10 days old.

short duration. The dodder root has no means of penetrating the soil, and at best is only slightly and temporarily fastened to the soil.

The stem lies coiled up in the dodder seed, and, with moisture, air and heat added, the coats burst irregularly, the root tip protrudes, and finally the stem, like a coiled watch-spring, is pulled out by means of an upright "loop," that constantly elongates until the tip is free, it having, in the meantime, absorbed the large stock of endosperm that was packed around the embryo. The iodine test shows that the young stem, as it is being extracted from the seed-coats, is gorged with starch, the amount gradually diminishing as the root end is approached. The root itself contains very little starch, save in certain cells near to its tip.

Usually, a short distance from the end of the slender stem, there is a peculiar notch, that may be considered as locating a rudimentary leaf. The tip is also irregular, but there are none of the well-recognized elements of a formed bud.

Through the root and the stem extends a central cord of fibrous tissue, easily distinguished from the parenchyma of the main portion, that surrounds it equally on all sides. It is unbranched, and more of the nature of a tendril of squash than an ordinary stem.

Plate XII. shows various stages in the germination of the dodder plants, all selected from seedlings that were between four and ten days old. The sharp-pointed nature of the young roots, as they first come from the ruptured seed-coats, is shown in the younger specimens at the right and left sides, while the long, slender stem above the somewhat larger root portion is shown in the more central specimens. The peculiar "loop" near the small stem end is seen in some of the other seedlings. Often the seed-coats are carried up at this bend, and may be moved through circles described by the rotating stem, that very early develops the tendency to seek some object of support.

By growing the dodder seedlings upon soil covered with lamp-black, it was possible to photograph these nearly white stems. That they are much influenced by light was determined by growing the young plants in saucers, so placed that one side only received the light through a small hole in the dark chamber.

The dodder was cultivated in the greenhouse upon several host plants, the most interesting of which was that upon the buckwheat. Seeds of a species *Cuscuta Polygonorum* Eng., found abundantly upon smartweeds in the neighboring low grounds, were sown along with the buckwheat, in pots. The above species was selected because its

ordinary hosts, the smartweeds, are closely related to the buckwheat. In some trials upon smartweeds in the greenhouse, it is quite evident that the buckwheat is not the first choice of this dodder ; but, nevertheless, the parasite secured a foothold and developed clusters of flowers of considerable size. There was one serious enemy to the dodder, namely, plant lice, that interfered with the experiments, and only by constant watching were any results obtained. The lice seemed to leave everything else in the greenhouse for the tender feeding ground furnished by the delicate young stems of the dodder, and were they at all numerous in clover or flax fields, it would seem that there could be no harm done to those crops by these slender plant parasites. In case of the buckwheat there was a formation of considerable enlargements of the stem at the places entwined by the dodder. Stems will make a similar growth when stung by insects, and it may be that the attacking plant so irritates the host that an abnormal growth follows. It may be an attempt on the part of the buckwheat to overcome the enemy strengthening itself at a place otherwise weakened by the enemy. Plate XIII. shows the dodder upon the buckwheat stem.

When dodders climb up woody stems of more than a year in age no such increase in size is usually met with. Along ponds and streams, alders, birches and other shrubs may be found with dodder fastened to twigs that are several years old, but they prefer the young twigs, and may reach them at the top of a button-ball bush, for example, by climbing up some vine and then spreading out upon the top of the shrub. Impatiens has a succulent stem, that is a favorite of the dodders, while any annual weed will answer for the "stepping stone" to higher feeding ground. Clematis and *Mikania scandens* are climbing plants that the little parasitic twiner finds a successful means of getting up in the world.

Notes Upon Dodder.*

* The following notes are taken largely from the Experiment Station Record:

Delaware Bulletin 5, June, 1889, F. D. Chester. Under inspection of seeds it was found that "in one hundred and forty-eight samples of seeds sold in Delaware, * * * five contained dodder." E. S. R., I., p. 24.

Colorado Bulletin 8, July, 1889. "The parasitic dodder (Cuscuta) is described, and farmers are urged to prevent its introduction with alfalfa by taking care to purchase pure seed." E. S. R., I., p. 190.

New Mexico Station Bulletin 2, October, 1890, p. 2. "The dodder (*Cuscuta trifolia*) is very troublesome in this region." E. S. R., II., p. 419.

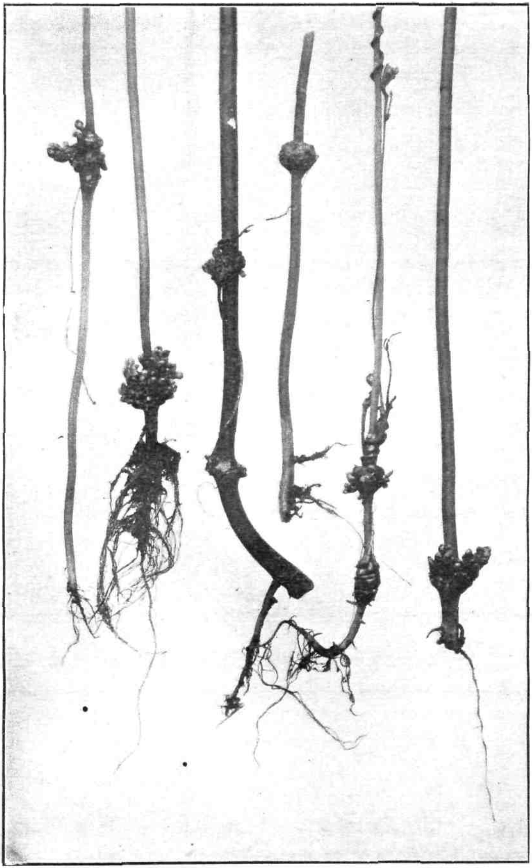


PLATE XIII.

Dodder plants as grown upon buckwheat in the greenhouse.

Nevada Station Bulletin 15, January, 1892, p. 8, Dodder, F. H Hillman (Fig. 5), gives a general account of plants of the genus Cuscuta and brief descriptions of *Cuscuta epithymum*, *C. arvensis*, and *C. denticulata*, with suggestions regarding means for the repression of these parasites. The first-named species is prevalent on alfalfa in Nevada. Seeds of *C. arvensis* were found in imported alfalfa seed. The first year's growth of alfalfa (from three seeds) showed the effect of the presence of the parasite in the yellowish-red patches of repressed plants, about which the dodder formed a dense mat. E. S. R., III., p. —.

Weeds of Calfornia, E. W. Hilgard, pp. 238-252, mentions in list of troublesome weeds, *Cuscuta trifolia*, *C. salina*. E. S. R., III., p 598.

Weed Pests, L. H. Pammel, pp. 72-72, mentions dodder (*Cuscuta trifolia*). E S. R., III., p. 217.

Oregon Weeds, M. Craig, Oregon Station Bulletin 19, May, 1892, p. 21, plate 19, mentions dodder (*Cuscuta racemosa*) among "the worst weeds in Oregon." E. S. R., IV., p. 47.

Contributions from the botanical laboratory and seed-control station of Hamburg, *No. 3, 1883, O. Burchard, p. 20. In the investigation for dodder seed in 60 samples* of red clover, 28 were absolutely free from dodder, 4 contained from 4 to 10 per pk., and 28 contained from 14 to 11,310 per kg. The species most common was *Cuscuta trifolii*, with occasionally *C. Europea*, and more rarely *C. epilinum*. The species found in North American seed was principally *C. racemosa*. The white *clover examined gave 50 per cent. dodder free, the rest containing from* 12 to 684 seeds per kg. Alsike clover gave 42 per cent. free, and the rest from 36 to 1,129 seed per kg. One lot of lucern from South America contained 23,600 seeds of C. chilonsis per kg., and no samples were dodder free. Yellow clover was free from dodder in every case. In two samples of timothy 20 to 284 seeds of *C. epithynum* were found. E. S. R., V., p. 334.

Weeds of Ontario, J. H. Panton (Ontario Agricultural College Bulletin 91, November 15, 1893, p. 7, Fig. 4), mentioned among 25 worst weeds in Ontario dodder (*Cuscuta trifolii*). E. S. R., V., p. 529.

Concerning the origin of American clover seed, O. Burchard (Landw. Vers. Stat. 43, 1893), Nos 3 and 4, pp. 239-346.

Named among a list of seeds that characterize all American clover seed, probably Cuscuta racemosa of that from the Eastern and Atlantic States. E. S. R., V., p. 912.

A method of destroying dodder. *C. Servais* (Ingen. Agr. Gembloux 5 (1895) No. 8, pp. 354-355). The plants on the spots where dodder is present are carefully removed and burned, the spot is worked with hoe or rake, and orchard grass or some other quick-growing species is planted on the infested spot. The author states that dodder thus treated may be entirely eradicated within two years. E. S. R., VI., p. 823.

Notes on the chemical history of Cuscuta, G. Barbey (Jour. Pharm. et Chem. 6, ses. 15 (1895) 11, No. 3, pp. 107-112), E. S R., VII., p. 407.

On the destruction of Cuscuta, L. Degrully (Prog. Agr. et Vit 12 (1895), No. 51, p. 655).

Methods are suggested for the eradication of the various species of this plant. E. S. R., VII., p 511.

Dodder on garden vegetables, *B. D. Halsted*; Garden and Forest *9 (1896)*, No. 646, pp. 565, 566, pl 1. Notes are given on a species of Cuscuta growing on onions and eggplants. E. S. R., VIII., p. 234.

An attempt to combat dodder and Rhizoctonia of alfalfa. L. Degrully. (Prog. Agr. et Vit. 26 (1896), No. 31, p. 115.) The use of crude ammonia is recommended. E. S. R., VIII., p 234.

A tobacco sickness of soil (Bu. Baden Landw. Bot. Ver. Sta. (1896) abs. in Ztschr. Pflanzenkrank 6, 1896 No 3 p 185). Notes are given on the presence of *Cuscuta Europæa* on tobacco. E. S. R., VIII., p 240.

Dodder in alfalfa (Agr. Jour. Cape Colony 10 (1897), No. 11, pp. 619–620). It is recommended to cut the alfalfa from the spots where the dodder occurs and cover them with 6 inches of manure, treading it down well. This kills the dodder and leaves the alfalfa to grow up through the manure. An application of a solution of one pound of sulphate of iron per gallon kills the dodder without injuring the alfalfa. E. S. R., IX., p. 143.

Cuscuta monogyna on grapes. A. Rolloff (Ztschr. Pflanzenkrank 7 (1897), No. 4 p. 213). The occurrence of this species of dodder on grape vine is mentioned, and placing finely-cut straw thickly about the vines is recommended as a preventive means. E. S. R., IX, p. 653.

Dodders infesting clover and alfalfa, L. H Dewey (U. S. Dept. Agr. Division of Botany Circ. 14, p 7, Fig. 3. Notes are given on the occurrence of some injurious species of dodder, methods of propagation, distribution and suggestions for their eradication. The species in the United States which are considered injurious to economic crops are the following: Alfalfa dodder (*Cuscuta epithymum*), flax dodder (*C. epilinum*), clover dodder (*C. racemosa chiliana*), warty dodder (*C. indecora*) and field dodder (*C. arvenses*). E. S. R., X., p. 54.

Two phanærogamous parasites of red clover, B. D. Halsted (Bull. Torrey Bot. Club. 25 (1893), No. 7, pp. 395-397, Fig. 1). Notes are given on the parasitism of Cuscuta epithymum. E. S. R., X., p. 556.

Twelve of Idaho's worst weeds, L. F. Henderson (Idaho Sta. Bull. 14, pp. 91-156, Fig. 5). Dodder is mentioned in a description of 12 worst weeds of Idaho, together with the methods of which they are distributed and suggestions for their eradication. E S. R., X., p. 760.

Cuscuta monogyna on the grape, P. Viala and G. Boyet (Ann. Ecole Nat. Agr. Montpelier, 10 (1897-98) pp 279-304, pl. 1, Fig. 32). A botanical study of this parasite of the grape vine. The seeds are said to retain their vitality for 2 or 3 years in the soil, and by care the plant can be exterminated from a vineyard in that time. E. S. R. XI., p. 159.

Dodder affecting alfalfa, E Schribaux (Prog. Agr. et Vit.) (Ed. L'Est), 20 (1899). No. 34, pp. 229-236; Rev. Gen. Agron (Louvain), 8 (1899), No. 8–9, pp. 373-377). The author describes *Cuscuta Gronovii* and states that it is frequently present in American clover and alfalfa seed. E. S. R., XI., 462.

The American Cuscuta, E. Schribaux (Jour. Agr. Prat, 1899, 11, No. 38, pp 418, 419, pl. 1). The author figures and describes *Cuscuta Gronovii*. On account of the fact that this species is said to be parasitic upon a number of plants, the author thinks that there is danger from its introduction into fields of forage plants. E. S. R., XI, p. 750.

Destruction of Cuscuta by copper sulphate, A. Brandin (Jour. Agr. Prac., 1899, II., No. 36, pp. 335–336) E. S. R., XI., p. 750.

The occurrence of a new species of Cuscuta on alfalfa, E. Schribaux (Jour. Soc. Agr. Brabant-Hainaut, 1899, pp 716–718).

Dodder on cucumbers under glass, F. C. Stewart, N. Y. State Station Bulletin 164, with plate. Reports the occurrence of dodder, probably *Cuscuta Gronovii*, on cucumber plants in the station hot-house. E. S. R., XII, p. 56.

The life history of flax and clover dodder, G. Wildsdorf (Fuhling's Landw. Zig., 48). Studies are reported on dodder seedlings, with reference to the host plant, the haustoria and methods of attack, and growth and reproduction of the dodder. E. S. R., XII., p. 313.

Alfalfa as a hay crop, B. C. Buffum (Wyoming Station Bulletin 43). Dodder is noted as one of the serious foes of alfafa in Wyoming. E. S R., XII., p. 431.

Geographical distribution of the species of Cuscuta in North America, A. M. Cunningham (Proc. Ind. Acad. Sci., 1898, pp. 214-215). Notes are given on the geographical distribution of the dodders into the different life-zones, as defined by Dr. C. H. Merriam. E. S. R., XII., p. 720.

The germination of ripe and half-ripe dodder seed, W. Kinzel (Landw. Vers. Station., 54, 1900, Nos. 1-2, pp. 125-132). Studies are reported upon the germination of seed of various degrees of ripeness of *Cuscuta epilinum*, *C. epithymum*, *C. plantiflora* and *C. Europæa*. It was found that the half-ripe seeds of these species retained sufficient vitality to germinate almost as readily as the fully-ripe seed. In some cases they germinated quicker than ripe seeds, and when they were found in their capsules the percentage germination was but little inferior to well-ripened seed. The author says that *C. plantiflora* is occasionally found in American clover seed. This seems to be a misstatement, as that species does not appear in any of the recent systematic treatises of the flora of this country. The species is a South European one, and its reputed presence is probably due to a wrong determination. E. S. R., XII., p. 960.

SELF-FERTILITY IN BUSH BEANS.

In order to obtain a full demonstration of the statement that beans are self-fertile, several tests were made in the greenhouse. Bush beans of the "Saddleback Wax" sort were grown in pots; as the plants neared the time of blooming all were removed, and the single plant covered with a glass bell-jar. As the flower-buds appeared, they were all removed excepting one, which was allowed to bloom entirely alone upon the plant. There were six such plants, with their single blossom isolated, and they all produced pods of normal size, possibly larger, perhaps due to the lack of competition for the nourishment, and yielded the ordinary number of seed. The last lingering doubt as to the self-fertility of this bean was removed. Similar tests were made with peas with like results, and it seems to be a fact that these species, with their strangely-formed blossoms for attracting insects, and securing wide fertilization when left to themselves, do not fail, but inbreed with apparent regularity and ease.

The Dwarfage of Beans by Cutting the Seeds.

Experiments have been made by growing "Saddleback Wax" beans from seeds that had been cut through shortwise, so that the food substance was reduced one-half. This can be done by first soaking the beans until they are softened, when they cut easily; and of the two halves, one will contain the seed-bud (plumule) and the other is made up of the free ends of the seed-leaves (cotyledons). If one is in doubt as to which is the bud end, the entire lot of halves can be planted; of course only the portions containing the stem and root will grow. Such halved beans, when planted in parallel rows with the whole beans, will demonstrate that they will germinate a little quicker than the normal beans, doubtless due to the greater ease in taking up the content of water. The plants from whole beans, however, soon pass the plants from the halved seeds, and in the course of three weeks are in every way larger. At the time when the former plants are in bloom, the others are only showing small buds. The plants from whole beans produced stems twenty-four inches high, while the halved beans gave plants only fourteen inches in height.

This experiment indicates a line of work to reduce pole beans of the common and lima sorts to bush varieties and any other plants, the dwarfage of which may result in plants of increased value.

In the second place, it emphasizes the value of a large amount of food substance in the seed and the importance of selecting those that are well provided in this respect. Large seeds other things being equal, are superior for plant production, because they have a larger percentage of material for the plant to use while getting started in the soil and air.

A similar study was made of corn, in which it was found that a large part of the starchy material may be removed, and the embryo, if uninjured, will begin growth much quicker than in a whole grain. It teaches the lesson of the advantage of rapid access of water to the center of the seed, and suggests that for large, hard seeds it may be practicable to slightly mutilate the outer portion, so that imbibition may be materially hastened.

THE SIMPLE-LEAVED AMPELOPSIS.

Specimens of the *Ampelopsis cordata*, kindly furnished by Professor Kellerman, of Ohio University, have been grown for two seasons as trellis plants upon the greenhouse. They are rapid-growing vines, with a foliage resembling the smooth-leaved grapes, which has the charm of holding on and remaining green for a month after the leaves of the American ivy have become discolored and fallen away.

Seeds of the same species were sown in the greenhouse and the seedlings set this spring in the Experiment grounds. These made a fine growth and are ready for setting as piazza covers the coming season.

REPORT OF THE ENTOMOLOGIST.

REPORT OF THE ENTOMOLOGIST.

JOHN B. SMITH, SC.D.

GENERAL REVIEW.

The season of 1901 was not marked by any unusually destructive insect invasion. Some forms became abundant for a time, and caused alarm ; but the threat was, in most instances, not fulfilled, and in no case was there any wholesale destruction. Yet the aggregate loss has been nearly as large as usual, some crops suffering more, as others suffered less.

The meteorological conditions were peculiar. The spring was late, cold and wet, retarding vegetation and favoring the development of certain plant lice. Then came a period of hot, dry weather, which burnt up pasture and, in turn, checked the growth of crops. The development of the early insects was also stopped, to the advantage of an altogether different series. When the drought was finally broken, moisture became excessive, and, in some localities, caused almost as much injury as its lack had previously done. Conditions were, therefore, irregular and abnormal, and a corresponding irregularity was observed in the insect occurrences. So, while the preceding note expresses the general condition, not all parts of the State were equally affected, some having no excess of rain at any time, while others did not get all the drought. Insects are very sensitive to weather conditions, and it is quite probable that some of the unexplained differences in local abundance or distribution may be eventually found to be due to even a slight variation in climatic condition.

Caterpillars.

One of the most characteristic features of the season was the increase in certain species of caterpillars, which, always more or less obtrusive, came this summer in destructive swarms. Others, ordi-

narily rare, occurred in such notable numbers that they attracted attention, and many species were, in consequence, sent to the department for information.

Fall Web-Worm.

The most prominent of these was the "fall web-worm," which, in late summer and early fall, stripped the leaves from orchard and shade trees, defoliated shrubs and vines, and made itself obnoxious by crawling into all sorts of unexpected places or dropping upon those walking beneath infested trees.

This increase was not entirely unexpected. For two years last past I had noticed a general occurrence of late nests, and in July, 1901, I found an unusual number of moths. I was not surprised, therefore, to note early in August the beginnings of numerous nests on my fruit trees and on the shade trees of the city. I depended at first upon picking off the leaves or small shoots as soon as the webs became visible, and for a week or two anywhere from one to half a dozen colonies were destroyed every day on almost every tree other than peach. Yet the colonies kept coming, and finally I gave all the trees a heavy dose of arsenate of lead. That settled the matter, and all the later colonies were killed off as soon as they began to feed; not another web developed on any of my trees.

The story from other portions of the State was the same, though very few persons realized the extent of the increase until whole trees were covered. Then came a feeble attempt to burn out the colonies; but though this method does very nicely where nests are scattered, and no tree has more than one or two, it fails practically when an entire tree is spun up. The torch in such cases is liable to cause at least as much injury as the caterpillars could do if left to themselves. By the middle of September curious sights appeared; orchards as bare of foliage as in mid-winter, with wilting apples or pears scattered about; vines with leaf stalks projecting from the stems, but not a shred of leaf tissue left, and shade trees bare, or festooned with torn and abandoned nests.

Not all kinds of trees were equally infested, and, among orchard trees, peach escaped almost altogether. Conifers were not attacked and some varieties of maple suffered little. So, the infestation was not equally bad everywhere, and locally only isolated trees would be much infested.

During September, demands came for information concerning remedial measures and inquiries concerning probabilities for next

season. It was then too late to adopt destructive measures, because the larvæ were practically full grown, and had scattered. From the middle to the end of September they were crawling about everywhere, not eating much, but evidently seeking a place to spin a cocoon.

Probabilities.

It is never quite safe to prophesy concerning an insect for a year to come, but judging from past history and from observations made, it seems safe to predict that the crop of 1902 will be much smaller than that of 1901. Parasites in great numbers were observed in and about the nests. I watched one specimen of *Pimpla* for nearly an hour, during which time she examined almost every larva in the web and laid an egg in most of them. Some were rejected for reasons that I could not discover, but no egg was laid before the caterpillar had been rigidly scrutinized.

A disease became epidemic among the insects late in the season. An occasional dying caterpillar could be observed even in August, and early in September dead specimens were not at all uncommon. Before the end of the month, dead, dying or mummied examples were on every fence, tree and shrub, and additions were constantly made to the number of moribund subjects.

Remedial Measures.

The "web-worm" is a chewer of food, or mandibulate, and feeds on actual leaf tissue. If we poison this the caterpillar eats of it and dies. This contains the essence of our practice against the insect; but to be entirely effective, applications should be made as soon as it appears that nests are to be abundant. Theoretically, the first brood hatching from the eggs in spring should find the foliage thoroughly poisoned. It is almost as well, however, to defer action until the first brood has gotten pretty well along, as a thorough application then made is likely to be more generally effective than one made earlier. For the second brood, spraying should be made as soon as the small colonies begin to show in any number.

I have used arsenate of lead and Bowker's "Disparene," which is its equivalent, with exc llent effect. The mixture was strong—about one pound in five gallons of water—but I did not harm even the most delicate foliage. On orchard trees Paris green will be cheaper, but in the garden I strongly recommend the arsenate of lead.

As many inquiries have been made concerning the effect of the defoliation on the trees, it may be added that Dr. Halsted does not anticipate any permanent injury. The leaves were fully mature in most cases, their functions had been pretty well completed, and their destruction did not leave the tree much the worse, though it did affect the maturing of such crops as were borne by them.

White-Spotted Tussock Moth.

Another common species that occurred in unusual numbers was the white-spotted Tussock or Vaporer moth. The pretty caterpillar, with its shining red head, its prominent black hair pencils, the small coral-red warts on its yellow body and thick paint brushes on its back, was seen everywhere in city, town and village streets, and attacked a great range of plants. At Riverton they attacked the Cannas on the Dreer nurseries, and it required prompt and vigorous action to destroy them. The species did not become abundant in orchards, for there our native birds keep it in check, but within the area of sparrow domination it flourished.

Some complaint was made of an irritant poisoning caused by the caterpillar, and this was partly based on facts. The hair of the larva is used to form part of its own cocoon, and, to facilitate felting or interlacing, some of it is spurred or barbed. A rough handling of the individual, and a rubbing of any of these barbed or spurred hairs into the skin, will set up an unpleasant itching, which may last for a day or only a few minutes. Rarely, with this species, is there any swelling resembling hives.

There are two broods of this species, and the last, which matured in September, was most troublesome. Again there was a demand for remedies, and, long after there was any chance of accomplishing anything, trees were banded with cotton and the like.

Probabilities.

The prediction made for the "fall web-worm" applies essentially to this species also. There was also an epidemic disease, though not so universal and quite different in character. Its effect was to change the larval tissues to a soft, pasty mass, and many caterpillars could be seen in early September, hanging limp and lifeless, supported in position only by a pair of the feet, which were hooked firmly into the surface on which they rested. Parasites were also plentiful, males

especially appearing to be attacked. Out of thirty or forty specimens of male pupæ gathered at one time from one fence, not one produced an adult, and from nearly all *Hymenopterous* parasites were bred. Nevertheless, egg masses were quite numerous late in September, and it is possible that there will be trouble next summer.

Remedies and Preventives.

Against this species winter work is practical and may be made very effective. The egg masses are prominent and so easily recognized that almost anyone can be directed to gather and burn them. This done there will be very few larvæ of the first brood the season following. When the larvæ do come in numbers, arsenical poisons are indicated as prescribed for the preceding species.

Catalpa Sphinx.—This insect was described in the report for 1900 and its invasion of our State recorded. During the season of 1901 it has not only held its own but has added new territory. The caterpillars now occur throughout South Jersey, not only in or near towns, but at the outskirts of and in the pines, where *Catalpa* is not uncommon. Near New Lisbon the trees in late August had not a leaf remaining, and at several other points the same appearance was noted. On the first day of October half-grown caterpillars were received from Flemington, indicating a very late brood compared with the Burlington county *status*. Most of these, however, it was later reported, died off as the result of a fungus disease.

But though the spread northward, along the Delaware, has been extremely rapid, the eastward journey through the central and northern section seems to be much slower. Though I looked carefully for the insect in the nurseries on the costal region, no trace was found, and local observers have seen nothing of it. The nearest approach to the Atlantic shore is Manchester or Lakehurst, in Ocean county.

Tomato-Hawk Moth.—About mid-summer, complaints of the "horn-worm" came from tomato-growers all over South Jersey; and this for a time threatened injury. There was considerable foliage devoured and some plants were really destroyed; but in most cases growers resorted to hand-picking, or, when the fruit was not too far advanced, to the use of arsenites. After the middle of August little was heard of the caterpillars; but the moth became commonly noticed. On one day Mr. Dickerson brought in about twenty, which were taken

along the bridge crossing the Raritan, at New Brunswick, and he could have taken more than as many more without difficulty.

It may be noted, incidentally, that arsenate of lead is the only safe form of arsenical poison to use on tomatoes.

Swallow-Tail Butterflies.—Among the rarer caterpillars that occurred in unusual numbers during the summer, those of four species of the swallow-tail butterflies attracted considerable attention. The most common was the one feeding on parsley, carrots and similar garden plants, and this is the larva of the *asterias*, or black swallow-tail, having an oblique bar of yellow spots on all the wings.

The second species was larger, with a swollen fore-body, a black, transverse mark back of the head, and two eye-like spots on the sides. This feeds on magnolia, sassafras and a number of other garden plants. It is the larva of the *turnus*, or yellow swallow-tail, in which the wings have a broad, black margin.

The third, and least common, is a peculiar grayish and white-mottled form, larger than either of the others, and was found only in gardens, on fraxinella and other ornamental plants. It is the larva of the *cresphontes* butterfly, larger than either of the others, black, with crossed yellow bars on the wings. This species is more common to the southward, and its larva is there known as the "orange dog," sometimes doing considerable mischief in Florida, on citrus trees.

On the *Aristolochia*, or Dutchman's pipe, the black larva of the *philenor* butterfly, with its long, black, soft processes, was very common, and some of the vines were almost or quite completely defoliated. These are scarcely injurious species ; but as the caterpillars were unusually numerous and really attracted considerable attention, it is deemed proper to mention them here.

One of their peculiarities which was usually referred to by correspondents was their habit of protruding a pair of fleshy tentacles from behind the head, when irritated. These are defensive and emit a disagreeable odor, which deters most things from meddling with them.

Plant Lice.

This could hardly be called a plant louse year, and yet considerable injury was caused by some of the species during the early parts of the season. While it was yet wet and cold in spring, the form affecting maples began to develop quite raidly ; Norway maples, especially, became badly infested and, in some of the cities and towns, "honey dew" appeared on the sidewalks beneath them. But the

Fig. 1.

Currant leaves attacked by currant plant louse. From an original photo—somewhat reduced.

natural enemies developed with their hosts and kept them down to reasonable numbers until the arrival of hot, dry weather put a period to the injury.

Currant Louse.—Currants became quite seriously infested locally, and, among others, the row of bushes in my own garden became quite lousy. I had kept rather a close watch early in the season, and April 26th found the winter eggs where I had noted the first feeding louse the day before, the position of the insect giving me an index to the place where its mates, then in the egg stage, could be found. This proved to be on the terminal shoots near the buds. So I followed the life history of the insect for a few generations, until its natural enemies and the increasing dry heat caused it to practically disappear. But the currants had suffered considerably and did not mature their crop properly. The leaves began to blister as soon as the first louse began feeding and continued until, on many plants, not a sound leaf remained. The material gathered in this study will be used at some future time, when the work can be completed.

Apple Lice.—Comparatively few apple lice appeared this year, but indications point to a more general occurrence next season, if the weather conditions do not interfere, and in some localities, even this year, there was noticeable injury, as will be seen by referring to the extracts from the Crop Bulletin. On trees where no aphids were noted early in the season a considerable scattering appeared in October. Oviposition is yet in progress at the date of this writing, and there promises to be quite a crop of eggs before it is completed. Up to the beginning of November the apple trees in the Experiment Orchard had more eggs than ever before in its history.

Woolly Apple Lice have not been nearly so abundant in the orchard or in the nursery ; in fact, colonies are exceptional as compared with last year. Cratægus is really the only plant upon which I have found them in numbers, and on this only in nurseries. It is one of the pests that is readily destroyed by fumigation except in the egg stage. I find practically none in heavy or clayey soil as compared with what is found in lighter, sandy land.

Strawberry Lice have become of importance, because delivered to purchasers of young plants in some other States. The species occurs throughout the southern, sandy counties, and has at times swept over fields in Ocean, Cape May and Camden counties. It is more than probable that it occurs in all the strawberry-growing

sections of South Jersey, though it has never done such injury as is credited to the species in Delaware and Maryland.

To inform our growers on this subject, and also concerning the strawberry leaf-roller, whose life history I had completed some time since, Bulletin No. 49 was prepared and distributed in March, 1901.

Melon Lice.—At one period in July it seemed as if there would be a serious invasion by this pest, and, as a matter of fact, some fields were actually injured ; but, the danger passed, the insects decreased in number quite suddenly, and nothing was seen of them later.

The Cherry Louse appeared in great numbers early in the season throughout the State and did serious injury to the crop locally. Throughout the month of June complaints were received, and, especially in the northern sections, fruit would not ripen or was actually caused to drop on account of the injuries due to these pests. They curled up the ends of the shoots, massed on the fruit spurs and even on the fruit stalks, sucking the juices to weaken the plant and coating foliage with honey dew to choke it. The usual black soot fungus appeared promptly, and altogether the trees were a mess.

Plum trees suffered to some extent, but not nearly so much ; while *Peach* escaped very easily. On the latter no real injury was caused, though some shoots were curled and twisted.

Woolly Maple Louse.—Besides the ordinary plant louse on maple, to which reference has been already made, a woolly species became locally abundant. A correspondent from Vineland sent specimens early in July, of which he says : "They rained down upon the head and shoulders of a company of people yesterday while sitting under a maple tree (*A. dasycarpum*). The ground under the trees and the piazza roof and floor were pretty well strewn with them. Some had wings and could fly ; but I was unable to find a specimen with wings this morning." Reports from other sections at about the same time indicate that this early part of July is the period for a general migration of the winged forms. There was no further abnormal increase, and the species was not again reported.

Phylloxera on Hickory.—From Morris and Cumberland counties complaints came of curious growths on hickory leaves and twigs, causing the foliage to shrivel, turn brown and to seriously check the tree. In one case the statement was that the trees had been affected for several years past. The abnormal growths were galls, made by a species of *Phylloxera* which is very common locally on the leaves of hickory sprouts. The galls are soft, bladder-like, and the inner surface is closely set with the yellow, black-winged lice.

I am not aware that the life history of this species has been completely worked out, and can make no present suggestions as to remedial treatment.

The Pea-Louse.

This insect has not caused so much injury in New Jersey as it did in 1900, and this was for several reasons. First, the season was against the insect and favorable to the plants; cold, wet weather retarded the development of the Aphid, and, though it also delayed the growth of the peas somewhat, the insect never really made up its loss, while the vines were all the better, the earlier varieties making exceptionally heavy crops. A second reason was that many growers accepted the suggestion made in my last report, and planted no peas to mature much after June 15th. Those who risked a later date, yet remained practically unharmed because of the weather conditions already referred to. Thirdly, many of those who grew oats and peas for late fodder last year, substituted some other crop in place of the peas. On the College Farm late peas were abandoned this year, because of the injury suffered during the two seasons last past. That this was good practice was indicated by the fact that in early September a row of late peas, planted for another purpose, was completely ruined by the swarms of lice. The crops maturing by the middle of June were unharmed. Finally, where peas were grown for canning, a systematic warfare was waged against them, and this was successful. It was indicated last year that two growers who raised a large acreage of peas had practically solved the problem of effectively dealing with this insect; but they were not quite ready at that time to publish results. The machinery employed has now been protected by patents, and no further secrecy is maintained. The growers are Mr. Asher Brakeley, of Bordentown, and Mr. Joseph Brakeley, of Freehold. The former grows about 500 acres of peas, the latter about 1,000, and in each case the product is canned, canneries running from the middle of June through most or all of July.

June 13th, Mr. Asher Brakeley gave an exhibition of the working of his machines on a 30-acre field near Bordentown, to which he was good enough to invite me. At this date there were few insects on the plants, and spraying was hardly a necessity except as it prevented any check to growth from a sudden increase, and barred the occurrence of large numbers altogether. It was said that the lice were at least two weeks later than in 1900, when the fields were swarming

at this date, and the crop harvested on the 10th had been already much injured.

Mr. Asher Brakeley disputed the suggestion that the winged forms came to the pea fields from clover. He has watched the insect for three years and, when it first came, lost considerable money by it. This year he again watched the vines closely, and instructed his partners and workmen to also watch and report the first appearance of any louse on the vines. There is no clover within several hundred yards of the pea fields, and no large fields of clover are within half a mile.

The first insects noticed were wingless; all the watchers agree on this, and all agree further, in the statement that no winged forms had been on the fields this season. There certainly were none on the 13th of June, so far as I could find, but I would not like to accept too positively the claim that none had been there early in the season. It is so easy to overlook the few migrants that come long before they are expected and disappear, leaving scattered young to form the little colonies which are afterward discovered as first appearances. That fields are very unequally infested is a common experience. Mr. Brakeley further asserts, and in this he is no doubt correct, that he has had fields of clover adjacent to peas and that the latter were practically free from lice, while other fields, distant from any clover patch, were practically destroyed. It is also certain that there has been no complaint in New Jersey of any plant-louse injury to clover. It is possible that the life cycle of the insect in our State is somewhat different from that recorded by Professor Johnson, in Maryland, the difference being due to latitude, but from a practical standpoint this does not seem to be material. The illustrations here given are from the "Rural New Yorker," and were prepared from photographs made for Prof. Sanderson, of Delaware, who was also at the trial, and who wrote an account of it for the journal just mentioned. Each sprayer consists of an oblong tank holding about 100 gallons. It is of wood, lined with zinc, and divided lengthwise into two compartments to prevent too much splashing. In the centre is a single-action force-pump with six-inch stroke, geared to the axle, a chain and sprocket giving four revolutions of the pump wheel to one of the wagon-wheel. A pressure of 30–35 pounds is obtained in this way. The pump is entirely inside the tank, and the gear is to one wheel only. This makes even driving rather hard, and the pump rather difficult to get at in case of accident. Below the wheel-

Fig. 2.

Spraying a pea field; upper figure shows the Brakeley Sprayer in action; lower figure shows a supply tank for spraying mixture. (From Sanderson in the "Rural New Yorker.")

body is a rigging of iron tubes and rods, which may be raised or lowered at will by means of a lever.

The machines spray three rows at one time, and twenty-one nozzles are arranged so that an adjusted series of seven sprays each row of vines as the machine moves along. For each row there is a series of spreading tubes, two of which, when the machine moves along, run at the surface of the ground in such a way that they pick up, by going under, every plant that is lodged. These tubes rise and narrow inwardly, so that the vines are at once lifted and brought toward the center of the row. Similar solid rods, also spreading anteriorly and narrowing to the centre, engage the vines and keep them erect, so, when they pass the nozzles, they are as nearly upright as they can well be.

The nozzles are of the "Bordeaux" type, throwing a fan-shaped spray. One is directed straight down, one from the top is directed forward, another backward. On each side are two nozzles, adjusted at slightly different angles, so that every part of the vine is hit as it passes between the carrier guides. Thin, sloping boards at the sides of the carriers receive any lice that are knocked off, and, being always wet with the spray mixture, the specimens receive a full dose. The machine is carefully adjusted to match the planter used in putting in the peas, and as the sprayer follows the exact route of the planter in every case, the adjustment to the rows is perfect and no vines are torn.

The machines used by Mr. Joseph Brakeley differ somewhat. They spray only two rows at a time, because his planters are so adjusted; the pump shaft is geared to both wheels, which makes even driving easier, and the pumps are entirely above the tank, making them easily accessible at all times in case of need.

The material used is Good's potash whale-oil soap, No. 3, one pound in six gallons of water, and all those concerned agree that it is perfectly effective and absolutely harmless to the vines under all circumstances. It kills wherever it touches; but, of course, with even the best machinery, some specimens will escape, especially at the tip, where the method of vine growth protects specimens lodged at that point, but vines once sprayed are safe for ten days thereafter; hence, except for the very latest varieties, one spraying is sufficient to carry them through. So, while the number of lice on the thirty-acre field was not in any way a menace to the crop on June 13th, it was feared that a few days more might bring an increase sufficient to cause a hardening of the pods and consequent check to growth.

This indicates the middle of August for the beginning of oviposition by the females. It also suggests that if two sprayings at short intervals could be made at this period—say July 25th and August 3d—with either whale-oil soap or kerosene emulsion, a good effect would be produced by killing off the males, and thus preventing the fertilization of the females. The soap should be about one pound in four gallons of water, or stronger on hardier plants, up to one pound in two gallons of water. The kerosene emulsion may be the standard soap formula, used one part in ten of water, or the mechanical mixture, using 10 per cent. of kerosene. Of the two, the latter is preferable, and is less likely to cause injury to susceptible trees.

Euonymus Scale.—This is allied in appearance to the oyster-shel scale, and has been frequently complained of by gardeners and owners of ornamental plants. During the season of 1901, Mrs. E. M. Hamlin, of Haddonfield, kindly supplied me with material gathered at intervals of a few days, whereby I was enabled to follow the development of the species. It appears that there are two hroods, pupæ of the males occurring early in July, the adults themselves being numerous on July 13th. Larvæ appeared about the end of the month and during early August. The material accumulated and notes made will be worked over as soon as possible, and presented either in a bulletin or in a future report of this department.

Tulip Soft Scale.—This insect, while not so conspicuously ahundant as it was two or three years ago, was disgustingly common at numerous points throughout the State. For some reason, its excretions were much more abundant than usual, and attracted swarms of bees, wasps and flies. Indeed, it was this feature that generally directed attention to the trees and resulted in the discovery of the infestation. The little, predatory caterpillar to which I called attention in previous reports was always present, and in some of the samples sent me all the scales had been destroyed by this useful creature.

The Rose Scale.—During the season of 1901 I received from blackberry and raspberry-growers several lots of canes quite well covered with the Rose scale, *Diaspis Rosæ* Bouché, complaint being made that the new shoots were badly infested. As there is nothing unusual in a local increase of the species, especially where the plants are in dense rows, I attacbed no great importance to the matter, and did not even mention it in my report. But during the winter specimens kept coming in, and, from the communications received, it was apparent that the increase was much more general and important than had been believed.

With the assistance of Mr. Henry Pfeiffer, of Cologne, who supplied me with specimens throughout the summer, I followed the life history of the insect up to the period when egg-laying was general in fall. An outline of this life cycle will be given elsewhere at some future time. As to the actual injury caused, opinions differ; but certainly the insect is of no benefit to the plant. Just why the scale became so abundant is a problem, and until this is solved it is impossible to say whether the increase will continue, or whether there will be a prompt return to original insignificance. At all events, it is well to be ready to deal with the creature should the necessity therefor arise.

San Jose Scale.

Much less time has been devoted to this insect than in the recently-past years, though it has yet demanded more attention than any one other insect. It remains the dominant horticultural factor in certain sections; but its extension into previously-uninfested localities is more slow. Where it has become fully established, fruit-growers have faced the problem squarely, and have, generally speaking, decided to fight.

Some pear and apple orchards that have been infested for nearly or quite ten years are yet bearing fruit, and are a long way from destruction. On these trees the insect can be fought and kept in check without an unreasonable amount of difficulty. Tbe Keiffer pear, especially, is resistant, and bears without injury the most radical insecticide applications.

Peach and plum succumb most readily, and are, at the same time, most sensitive to insecticide applications, though the former is much more susceptible than the latter.

The main difficulty yet is to bring growers to a realizing sense of danger from the insect before they learn from actual experience. It is surprising, however, how much attack some trees will stand without succumbing. It is not even unusual for a tree, after several years of infestation, to become entirely clean without any treatment, and to remain so in the midst of infestation. These cases are too rare to be of great present importance, but their occurrence indicates the existence of a factor concerning which we are not yet informed, which may, at some time, give us easier control of the insect. The element of spread from infested nursery stock has been reduced to a minimum. There are yet a few local growers of peach stock on a small scale, chiefly in the northern counties, who probably distribute

some infested trees ; but they find it increasingly difficult to dispose of their stock. The dealers and growers that send stock out of the State or receive it from outside points are keeping the closest possible watch on all their growings, and all the larger establishments have built fumigating houses. Some of them fumigate all stock received as a matter of precaution, and some also fumigate to destroy such plant lice and other pests as are often distributed with trees and plants. Otbers fumigate only when requested to do so, or when the actual presence of some tronblesome species makes it seem desirable.

I have previously noted the fact that Osage orange hedges were frequently infested, and I have again verified this as a source of local infestation. The hedge plant itself seems not to suffer very much, and that makes it a continuous menace to the surroundings.

One thing seems now fairly certain, and that is tbat the scale is not a menace to our shade and forest trees. I have kept this point well in view, and, even in sections where almost every fruit tree has some scale, the usual shade trees have remained exempt. A row of maples in an infested Osage orange hedge were completely free from this insect, though thousands of crawling larvæ were round about, and had been for some years.

As to methods of treatment, nothing new bas developed. The crude petroleum is not only holding its own as the best destructive agent, but its use is extending continually. Over 40,000 gallons were used in New Jersey this past year, and over 1,000 gallons have been used by individual growers. We have over half a million infested trees in the State, and over half of tbem were oil-treated during the winter of 1900–1901.

Whale-oil soap is used to a considerable extent for summer applications, and, more rarely, for winter work on peach.

The lime, sulphur and salt wash was used in Burlington county by one grower with excellent success. Similar good results are reported from Washington, by Mr. Marlatt, who explains that an unusually long period of dry weather gave the insecticide a chance to become effective. The New Jersey application probably had a similar opportunity, and it is reasonably certain that, could we count on a dry period of three weeks, we could make this California mixture do equally good work here.

The chemical reactions are explained in Mr. Marlatt's account somewhat as follows : "The wasb, as finally prepared, contains a large amount of calcium sulphid, some of the higher sulphids of calcium, small amounts of calcium sulphite and a large amount of calcium

thiosulphate; also some of the excess of calcium or lime is in solution. The residue is composed of lime.

"If such a wash were applied to trees in a dry climate, the various compounds formed would remain for a long time, and only gradually decompose. Eventually, however, the calcium sulphid would decompose, most likely forming calcium sulphate and some hydrogen sulphid (H S), and the calcium thiosulphate would decompose, first setting free calcium sulphite, which last would oxidize to calcium sulphate. The lime would change to calcium carbonate ($Ca\ C\ O_3$) and the polysulphid would break down, yielding sulphur and calcium sulphid, which would, in turn, change as above.

"In a wet climate the calcium sulphid and the calcium thiosulphate would soon leach out, leaving behind small amounts of calcium sulphate and a large amount of lime, which would, in turn, form insoluble calcium carbonate. In this latter case the tree would still remain white and appear to still have the wash upon it, but, in fact, very little other than the calcium carbonate would be left."*

This means, briefly, that in dry climates the wash decomposes very slowly, giving off suffocating and poisonous vapors, acting continuously upon the insects that are covered by it. In the presence of moisture these compounds simply dissolve out at once, leaving only a good coating of ordinary whitewash.

In Mr. Marlatt's experiment, dry weather continued from March 23d, the date of application, to April 11th, a period of eighteen days. The effect of the wash upon the scales began to be noticed March 27th, four days after the application, and increased continuously thereafter.

For the benefit of those who may wish to use this material, the following formula used by Mr. Marlatt is given :

Lime	30 pounds.
Sulphur	30 "
Salt	15 "
Water	60 gallons.

The mixture was steam-boiled about four hours and applied hot.

Recommendations as to the method of preparing the mixture vary somewhat, but the following seems indicated : Slake half the lime, add all the sulphur and boil until thoroughly dissolved. Then slake

*Bull. No. 30, New Series, U. S. Dept. Agl., Div. of Ent., p. 35, note. The analysis was made by Mr. J. K. Haywood, of the Bureau of Chemistry, and reported by Dr. H. W. Wiley, Chief Chemist.

the balance of the lime, add the salt during the boiling so as to dissolve it all, then combine the two mixtures and boil for two or three hours longer.

It should be added that, in the vicinity of Freehold, Mr. L. F. S. Schanck, a commissioner under the State law, served nearly 200 notices to clean trees from scale, where infested trees were known or suspected to exist. This had the effect of arousing inquiry, and Mr. Schanck's report is that in almost every instance owners of infested trees responded readily when the situation was explained to them.

SHADE TREE INSECTS.

A number of species that come naturally under this heading have been elsewhere referred to; but there are some others that may be noticed.

The first of these is the *Elm-leaf beetle*, which has fully recovered from its temporary check, due to the epidemic disease noted for the three years last past. The insects were very abundant this year, not only at New Brunswick, but in other parts of the State. In many places the foliage was completely destroyed or so browned and disfigured as to be an eyesore and of no use to the tree. Timely rains admitted of a new start of foliage, and enough was made to carry the trees safely into the winter. There was no trace of even a partial second brood of the beetle at New Brunswick; nor was the new foliage much eaten by the midsummer beetles; each individual seemed anxious to be out of the way as soon as possible, and very little was seen of them. No change has been made in methods of treatment, and nothing more reliable or effective than the arsenical sprays has been discovered. The effort seems now to be chiefly in the direction of securing more effective machinery.

The Wood Leopard Moth is spreading slowly, but is not nearly so injurious as it has been in its older locations. The moths are not nearly so abundant at the electric lights in the cities, and the trees are not dying off as in the past. At New Brunswick it is now all over the city, and I have found larvæ and pupæ in a number of branches blown down by high winds; but only a few cases have come to my attention where young trees have been girdled.

Maple-Leaf Stalk Borer.

A very interesting attack was reported on maple from South Orange during the latter part of May. The complaint was that each year, at about that time, certain maple trees began to drop their foliage, and that this seemed to be due to the work of an insect. A small lot of leaves, sent in at my request, showed what was, apparently, a small Coleopterous, or beetle larva, boring in the leaf stalk; explanation being made that, when the leaves dropped, the grubs remained in that portion of the stalk which adhered to the tree. During the early days of June I visited the grounds personally, and found two large sugar maples badly infested. Both were in full foliage and healthy looking, but under them some 25 per cent. or more of the leaves lay on the ground or had been raked up. From the observations made, it seems that the parent, which is assumed to be a Curculio, or snout beetle, gnaws into the stalks of the most vigorous leaves at a little beyond its middle, and there lays an egg. The young larva hatches in due time, and begins to eat toward the twig, completely hollowing out the leaf stalk. At the time that I saw the specimens, less than an inch had been excavated by the young larva. The leaves do not drop at once, and so long as there is plenty of moisture and no high wind they remain on the tree. When a dry spell comes on there is an insufficient supply of moisture for the leaves, they droop, and finally fall to the ground, breaking off at the point where the egg was deposited.

Mr. Dickerson made two other visits to the infested trees to secure material, and about the end of June the larvæ were full grown. They were then fully one-fourth to three-eighths of an inch in length, and fitted very tightly into the leaf stalk, which was now eaten to the point of its attachment to the twig. A lot of them were put into a breeding-jar with moist sand, and into this a large number of specimens buried themselves promptly; but, instead of completing their transformations, they decayed or dried up without exception. Each formed a small sand-covered cocoon or cell about an inch below the surface and then remained quiescent until all were dead.

After it became certain that my larvæ would not develop, Mr. Dickerson sought pupæ at South Orange, beneath the infested trees, but without success. The solution of this problem, then, must lay over until another year.

Bag-Worms.

From all parts of the State came complaints of the abundance of this insect. They began in May and continued until late August, coming chiefly from cities, towns and villages, where Arbor-vitæ and other evergreen hedge and ornamental trees were victims. Montclair, the Oranges, Cranford, Madison and the territory surrounding Newark and Elizabeth brought a large part of these records, and undoubtedly much real injury was done, because Arbor vitæ, once completely defoliated, is doomed. The season seemed to suit the insects exactly, and the increase late in summer was much greater, proportionately, than in past years.

As to remedial measures, I advised hand-picking where it could be done, and the application of arsenate of lead where a spraying was needed. A correspondent from Madison states that he used Hammond's slug shot with a bellows, and effectually disposed of the pest. It is probable tbat this material can be satisfactorily used in dry weather where the area to be treated is not too large.

In orchards the insect is well under control, because of the almost universal application of arsenical poisons for the destruction of other insects. It is curious how far the caterpillars will wander when full grown. In the Experiment Orchard there is one female bag at the tip of one Keiffer tree, and I believe this is the only example on the place. The nearest point at which it could have been hatched is over 200 feet away and outside the fence line.

An interesting experiment was made at Hammonton early in the spring. At this place the bag-worms had always been seriously injurious to shade trees, hedges, etc., and they detracted materially from the appearance of the streets. At the request of some of the members of the Council, I visited the town, and, after a consultation, it was agreed that Mr. A. Monfort, the Insect Commissioner under the State law, who was a resident there, should make a systematic inspection, should see all the owners, and try to obtain their co-operation in exterminating the pest. The governing body was to co-operate also in any way that was feasible.

Mr. Monfort made his inspection, served printed notices where necessary, and distributed copies of Circular No. 8, dealing with this insect, with which I supplied him.

The result is reported as very satisfactory, and shows what can be accomplished when a matter of this kind is energetically taken in hand.

ORCHARD INSECTS.

Observations and work in the Experiment Orchard were continued during the season; but the records are not included in this report. The trees have now been under continuous observation since the spring of 1898, and many lessons have been learnt from them. Most of the peaches and some of the pears began fruiting in 1900, and the peaches made a very decent crop in 1901. Some trees proved undesirable, and four peach were cut down to make way for others. Further re-adjustments being also necessary, it was decided to embody the complete records and their lessons in bulletin form. Though nearly all of the original trees were scale-infested when set, not a single tree has been lost through the direct injury caused by this "pernicious insect." They have had no better care than could be given by any man ordinarily attentive to his business; in fact, I would expect a commercial orchard to receive better care than I gave, in the direction of controlling plant disease. Two peach trees were taken out this fall simply because, while they set heavily and grew fine fruit, every bit of it rotted before it ripened, and I got not even a single peach. The trees were scaly, and always had been; but had the insect been alone concerned I would not have lost a fruit, and would have guaranteed a crop for 1902. In fact, none of the removals were due to scale injury. In this little area I used during the season of 1900 "Disparene," "Pyrox," Swift's Arsenate of Lead, Hammond's Thrip Juice, Rose-Leaf Tobacco Extract, "Kretol," "Yankee Yellow," petroleum of various kinds, potassium sulphide, and perhaps a few other materials that do not now recur.

Rosebugs.—There is always more or less trouble from this pest, but it is mostly local at present. There does not yet appear to be any threat of another such invasion as overran parts of Cumberland county ten years ago. Usually they are reported from gardens or on apples; but this year they seem to have taken a fancy to peach, eating both foliage and fruit. From Glenwood they were reported in especial abundance late in June, as many as twenty-five examples occurring on one peach. Nothing more effective than collecting the beetles in an umbrella or similar contrivance has yet been suggested.

Silky June Beetles.—A curious example of the occasional destructive abundance of an otherwise rare insect came from Atlantic county in May. For some days the silky June beetle swarmed on fruit trees, devouring the foliage so as to leave bare twigs only. One re-

port was that the smaller shoots were actually bending under the loads of beetles. They are about half the size of the ordinary June or May beetles, rather darker in general color, and with a beautiful, silky, iridescent covering. In such a case there is nothing to be done, except gather the insects by jarring, and dump them into a *kerosene pail. They do not ordinarily fly more than a few days,* and though they may devour a large portion of the foliage then present, the injury is not permanent. Yet it is altogether likely that it will be years before they appear again in similar numbers.

Plum Curculio.

The tax exacted by this species was unusually heavy. A correspondent from Monmouth county writes that if he knew the exact value of the apple crop in Monmouth county he could tell the extent of the injury caused by the Curculio and Codling Moth—in other words, just one half of the crop was destroyed. From what I saw myself, I think that rather a conservative estimate for other localities also; though of course, this percentage of loss does not hold for the State at large.

Atlantic county always suffers severely from this insect, and this year was no exception. A correspondent from Cologne wrote early in the summer that he had expected a heavy crop of peaches, and had them actually on the trees; but so great was the loss due to *Curculio* punctures that the harvest was really very light. The exact language in this case is interesting: "The Curculio has proved this season to be our most destructive insect. Owing to the very cool and wet weather this spring, I, with many others, supposed it would not be active enough to be destructive, and no preventive measures were adopted. The result is that our apple crop is completely ruined—75 per cent. of plums and 90 per cent. of peaches. Peach trees had all set well, and I expected several thousand baskets. This was reduced by the Curculio to about 200 baskets."

This correspondent has had San José scale on his place for several years, and the total loss suffered from this celebrated pest has not equaled a fraction of what the Curculio took this season!

Sinuate Pear Borer.

This miserable creature, while it has not been reported from any new localities, has held its own at New Brunswick, and I have found

it in *Cratægus*, imported from France, in the course of my nursery examinations. The latter point is of importance, since it emphasizes the necessity of a close scrutiny of stock received from abroad even when not strictly "fruit." Of course, all the infested plants were condemned; but, unfortunately, in some instances the adult had emerged during the early summer.

In the Experiment Orchard almost all the older pears are now infested, and in all probability new infestation has taken place. Two adults, at least, escaped from the trunks, and, as I saw several in the orchard, I have no doubt that the old trees, referred to in previous reports, added their usual contribution. At the College Farm a large proportion of the trees are infested—some very badly. Mr. Jordan went over them all with a knife, early in the season, and cut out larvæ and pupæ in great numbers—a dozen or more out of a single tree, in some cases. He found that, with a little experience, it was not difficult to locate the pupal cell by a slightly-discolored, flatly-depressed area in the bark at the end of the marks indicating the boring.

On my own trees I did no cutting, but tried to keep the beetles from getting out by wrapping with strips of cotton sheeting about four inches wide, wound round so as to cover the trunk from the surface well up into the branching. This was afterward drenched with water and coated with cement and milk. The intention was to make an impenetrable coating, through which beetles could not emerge. When the wrappings were taken off, after mid-summer, it was found that two adults had made their way through the covering —in each case, very close to the surface, through a single thickness of sheeting only. Evidently this sort of barrier is insufficient; but I will try it again next year, with some stouter material. I cannot be certain that some beetles were not kept in. Tree No. 20, which was taken out last year, had six full-grown larvæ, and the neighboring trees also seemed as badly infested. That only two beetles should mature in all the other trees argues some sort of check.

Pear Midge.

In the State at large and in well-cultivated orchards this insect is rarely seen nowadays. I found it last year on the first fruits in my Experiment Orchard, and destroyed the few infested pears. This season, in a light set of Keiffers, almost every pear was taken. What would have made a basket or two of fruit was reduced to less than a

dozen. This pest also is a contribution from a neighbor who pays no attention to his trees, and it gives me another species to experiment with. His trees are dying off, and so little fruit set on them that the insects were forced to seek new breeding grounds. My trees happened to be nearest by, and they got the crop. I picked off and destroyed infested fruit as fast as I saw it; but it is quite probable that some specimens escaped to bother me next year.

Incidentally, it may be noted that not an example of the Japan Golden Russet pears was attacked, though there was more young fruit on the two trees of this variety than on all the others combined.

INSECTS ON FIELD CROPS.

Taking the State at large, the *Hessian Fly* has done little damage. There have been some infested fields in the northern part of the State, and, in a few instances, the crop has been reduced to some extent; but there has not been any reduction of the crop in the State as a whole. This is due very largely to the fact that farmers have learned to delay seeding just as long as they possibly can. Very little is done in the southern counties before October 1st; and even in Hunterdon county the tendency is to hold off until that date, or even longer. At the Cornell Station, in New York, experiments were made with varieties of wheat, looking to the possibility of finding one that is "fly-proof." The results have been interesting, and, to some extent, contradictory. First, it seems that the Hessian fly has done injury in that State amounting to nearly three millions of dollars; second, it seems that one variety of wheat—the Dawson—stands out prominently from all others in that it is nearly uninjured. Summing up, in Bulletin No. 194, Prof. Roberts says: "Here, then, is indisputable evidence from the Station Farm and from nine other farms located in four different counties of the State where co-operative experiments were conducted, that Dawson's Golden Chaff has almost perfectly resisted the attacks of the Hessian fly during the season of 1901 in New York State, and that no other varieties that were compared have done so, although in a few cases, where the soil and conditions were peculiarly favorable, No. 6 and 'Red Rover' have made fair to good crops."

It should be added, however, that in Canada, the home of this variety, it is not in any way exempt from fly attack. On the contrary, so far as the records go, it is one of the poorest, from this standpoint. Other kinds have been found much more satisfactory,

and it proves, what has been suggested by others, that there is a difference in the behavior of identical varieties in different localities. While, therefore, it will not be safe for the New Jersey farmer to plant Dawson's Golden Chaff, with the idea of securing a wheat that is not attacked, it may pay him to plant it, in comparison with some of his other varieties, to test its value under local conditions. In fact, it is further suggested that farmers study their surroundings more closely than they have done heretofore, and, when they find a field of wheat which, in a fly year, is little or not at all infested, let them ascertain the reason for the exemption. It may be the date of sowing; it may be the character of cultivation; it may be the variety; and it may be a combination of all or any two of these factors.

"Dawson is a white chaff, bald wheat. The grain is so light an amber that it is sometimes classed as white. Heads rather short, but very compact, and yields beyond its appearance when standing."

The life history of the Hessian fly, and the general methods to be adopted in controlling it, have been given in the bulletins and reports of the Station, and there is little to be added to what has been already published. What should be emphasized is, that proper farm practice will go further to control the pest than anything else that can be done. One practical feature, which is at once the most effective and least generally resorted to, is to plant a decoy strip in early September. The object of this is to furnish a place which the flies will naturally select for oviposition. They will lay all their eggs by the middle of the month, if they get the opportunity; certainly before the end of the month, except in the case of long-continued drought. This decoy strip can be plowed under deeply, at the time the main crop is planted; or, if it is on another piece of land, the plowing can be delayed until the main crop makes its appearance above ground. Another important point is the thorough preparation of the seed-bed and careful seeding; in other words, give the plants every possible chance to make a vigorous growth, and the tendency will be to resist the attacks of the insects, even if made. Prof. Webster, of Ohio, who has studied the Hessian fly for fifteen years, is quoted as saying that he believes that four-fifths of its injury may be prevented by a better system of agriculture.

In this connection, the following from a "Winter Wheat" Bulletin of the Tennessee Station is suggestive: "The fertilizer plats were apparently not affected by the fly—the best argument that can be adduced to show the importance of having the land in excellent condition and well supplied with plant food. It is hard, on any other

basis, to understand why the fly should attack some of the varieties in contiguous portions of the field, and injure them quite seriously, and have apparently no effect on the fertilizer ranges."

Angoumois Grain Moth.

After the report for 1900 was prepared, complaints became so numerous and requests for information so urgent that, because the report could not get into the hands of the farmers in time to be of immediate service, it was decided to publish a bulletin for present distribution. This was handed in December 10th, and sent out early in the new year as Bulletin No. 147. In it was given a brief account of the history of the insect in our State and a full description of its life cycle, as an explanation for the detailed directions concerning its destruction or control. The main point emphasized was that threshing should be done as soon after harvest as possible and that stored grain should be bulked or sacked. During the season of 1901 this suggestion was largely followed, and, up to the time of writing, material damage has been reported from a few localities only. That the insect is yet doing mischief is proved by cases where grain could not be at once attended to. This was found to be infested when examined in stack or in shock, and here and there some infestation was noted in the bins on the upper surface. The tendency has been to either market or mill as soon as possible, and where storage was absolutely necessary sacking was generally resorted to.

In parts of Gloucester county, reports says, less wheat than usual has been planted because of the danger from this insect, and it may be that some Burlington county farmers have felt the same influence in determining the extent of their wheat area.

It is also probable that some millers, who have bought wheat apparently sound and placed it in bins, will yet lose some unless it is promptly worked up.

An encouraging featnre is the occurrence of a large number of parasites in every infested sample received. A few years ago, when this moth became destructive, the appearance of this parasitic form in number marked the end of the invasion. It is not safe to say that it will do so in this case as well; but natural forces undoubtedly are at work against it.

INSECTS ON TRUCK CROPS.

Rhubarb Beetles.—It is not often that rhubarb suffers from insect attack, or, if it does, the growers do not complain; but there is a species which, in the larval state, bores into the stalks and unfits them for market. It is not a new species; its habits and general life history have been long known, but, up to the present, there has been no record of trouble in this State. This year (1901) it made itself known at three different points, and it may be well to indicate the general line of treatment. This is simply to cut close throughout the season, taking all the older leaves, even if they cannot be marketed. If this is persistently done no larvæ can come to maturity, and the next year's crop of insects will be disposed of in advance.

Asparagus Beetles.—These insects have not been especially troublesome during the past season; they are always present, and both species were observed throughout the region where this crop is important; but no serious injury was caused. The only complaint received at the office was that they were defoliating the ornamental or foliage variety of this plant.

Tortoise Beetles.—Locally, these insects attracted attention on sweet potatoes, but were hardly more troublesome than usual. The vines, favored by the weather, got a good start in the spring and outgrew the insects rapidly. From Vineland a new form was added to our list in the "Argus" tortoise beetle—the *Chelymorpha argus* of the entomologist—and this is much larger than those more usually found on the Convolvuli, to which the sweet potato belongs. The normal food of this new pest is the sunflower, and, probably, the attack on "sweets" is simply a local aberration. If not, and it should threaten injury, the treatment is the same as for the other species of this group.

Another sweet-potato insect attacks the plants in the forcing-bed. Samples sent me from Salem county showed masses of mealy bugs clustered at the bases of the sprouts and of the small leaves. I have no idea that these creatures will survive the normal outdoor conditions when the plants are set out in spring; but they undoubtedly injure the growth of the shoot and make a weakling plant if it is set. Just how prevalent the insect is I do not know; but, where it occurs, the cellars or store-rooms should be thoroughly whitewashed and cleaned before the seed potatoes are stored. The temperature should be kept so low as is safe, and the bed in which the roots are forced

in spring should be entirely clean. It may be also well to look at the roots carefully before putting them in, and to reject all such as show the insect to be obviously present.

Potato Beetle.—In the extracts from the Crop Bulletin this species will be found referred to at some length. It has been indicated in previous reports that the insects have been rather broadening out their bill of fare, including tomatoes, eggplants and others of the less useful *Solanaceæ*. This season they have extended their range to the *Cruciferæ*, and have attacked turnip tops, in destructive numbers, in Atlantic county.

AN INJURIOUS ROOT CHAFER.

A curious phenomenon was the abnormal increase of one of the smaller leaf-horned beetles or chafers, known as *Ligyrus relictus*. This is smaller, chunkier and more roughly sculptured than the ordinary June bug or May beetle, to which it is otherwise allied. It is always common along shore, where it is a nuisance at night, but this year seems to have extended throughout the State in abnormal numbers. For several evenings walking was unpleasant beneath the arc lights at New Brunswick, owing to the number of these beetles covering the walks. It was impossible to step without crushing one or more, and the examples still on the wing struck hands and face in their blundering flight.

Never before had this been reported to me as an injurious insect, but now it is at hand from several points as a root-feeder. The most serious trouble was reported from the Dreer nurseries, at Riverton, where it attacked and fed upon the roots of hardy Pyrethrums. It was remembered then that about three years ago they were abundant at the roots of the hardy varieties of sunflowers.

Bearing on the same point, but just a little beyond our borders, a complaint came from Torresdale, Pennsylvania, that an entire crop of sunflowers had been destroyed and a bed of Cosmos attacked.

The larva is a white grub and feeds on decaying vegetable material, principally rotten wood. What peculiar combination of circumstances resulted in this abnormal abundance I cannot say, but there is no reason to expect any similar increase next year.

CRANBERRY INSECTS.

The only material point left incomplete in my previous study of the insects affecting this crop was the life history of the katydid, that eats into the berries and devours the seeds. This has been a sore point for several years past; but it has seemed impossible for me to get on the bogs at just the right time. All the other pests are fairly under control, and the methods of dealing with them are well understood; but "grasshoppers" have each year demanded a serious toll, and it has seemed impossible to get at them. This past summer I determined to make the completion of this study an "imperative," and with the co-operation of Mr. Joseph J. White, of New Lisbon, the egg-laying habits of the species were successfully determined. Growers may now act intelligently toward the destruction of this pest, and, fortunately, at a season and in a manner that gives full opportunity for thorough work. A full record of what has been done appears elsewhere in this report.

MOSQUITOES.

The mosquito problem is attracting attention wherever the pest occurs, and since a definite relation between the insect and malarial disease has been established, it has become important from a new point of view.

It has seemed to me that a study of this question, so far as it affects our State, was of importance to its agricultural interests, because there is no doubt that the abundance of the species near the shore and in certain other parts of the State prevents that growth of population that would otherwise furnish a local market for much of the truck grown in the State.

A part of this report is devoted to a statement of the investigations made, the results attained, and the work that yet remains to be done.

Briefly stated, the mosquito pest can be reduced by 50 to 75 per cent. by permanent works, that will be useful in other directions and should be done by the State. Of the remaining 25—50 per cent., all but 5—10 per cent. can be destroyed by municipal or individual action. It will require an appropriation of at least $10,000 to make a comprehensive survey and formulate a plan looking to the end above set out.

INSECTICIDE COMPOUNDS.

A number of insecticide samples were sent in during the year, and some were tested in the Experiment Orchard. The details are not material where the results were negative or inconclusive. It is not always fair to condemn upon the results of a single season's experience, and mere mention will be made of such cases to indicate the work done and the results aimed at.

Arsenate of Lead.—This was used on the foliage of orchard trees of all kinds, and very strong—about one 1 pound in 5 gallons of water. Not even peach foliage suffered in the least, while after its application not a brood of tbe web-worm developed on any tree. Rose plants infested with slugs were also sprayed and cleared. I gave away several parcels to neighbors, and in every case effective work was done, without harm of any kind to foliage. All these applications were of much greater strength than really necessary, and traces of the material remained for months afterward on the trunks and branches—indeed, after all foliage was gone; but the object was to find whether this was something which it was not necessary to employ carefully for fear of injury to plant life. Two samples were used—one made by the Bowker Fertilizer Company, of Boston, Mass., and sold under the name "Disparene," the other by Wm. H. Swift & Co., also of Boston, and sold as Swift's Arsenate of Lead. Both are in the form of a white paste, which mixes readily with water and remains well in suspension. At the strength at which these mixtures were employed by me there was no difference between them, and both are good.

The advantages of this material are its absolute safety so far as plants are concerned, effectiveness when used properly, ease of preparation and lasting qualities. It is the only form of arsenic that can be safely applied on evergreens, and for gardeners and growers on small areas it is the ideal insecticide against leaf-feeding species. At present prices, the prepared forms are too expensive for the orchardist, and Paris green or green arsenoid are more satisfactory.

It was intended to make comparative tests of the last-mentioned materials and other arsenical mixtures by spraying elms to kill elm-leaf beetles. But the date of the spraying period coincided very closely with a spell of intense heat, and, somehow, it was not possible for me to find the college janitors who were to do the work until it was too late to make the applications.

Whale Oil Soap, with and without the addition of tobacco extract, was applied to kill plant lice, leaf-hoppers and larval scales, in each case with excellent success. The material used was made by James Good, of Philadelphia, and left little to be desired. A somewhat more detailed reference to this material will be found elsewhere.

Tobacco Extract (Rose Leaf) was used against plant lice and leaf-hoppers with fairly good results. It did not stick so well as the soap mixtures in orchard use and did not so readily wet the insects.

"*Yankee Yellow*," a combination of arsenic and sulphur, was experimentally used with negative results. Theoretically, its composition should make it an ideal insecticide and fungicide, but, somehow, in practice, the results were unsatisfactory. Yet the material is deserving of further tests, and, if possible, experiments will be carried on next year.

Pyrox, a combination insecticide and fungicide prepared by the Bowker Fertilizer Company, was used on peach trees to check fruit rot, with almost disastrous results. Foliage and fruit were both killed where the application was thoroughly made, and no corresponding advantage was secured on the remaining fruit. Yet this does not condemn the material for use on other trees, for the peach is notoriously a sensitive subject.

Hammond's Thrip Juice was applied according to directions against the grape leaf-hopper, with a fair measure of success, but makes an expensive mixture compared with the whale-oil soap or tobacco extract. No harm was caused to foliage by the application, nor did it kill adult tree-hoppers to any extent.

Kretol is a soluble carbolic acid preparation which was tried against plant lice, leaf-hoppers and scale larvæ on currant, grape and apple. The result was unsatisfactory and inconclusive. The effect on the insects was not well marked, while the effect on the foliage, of grape especially, was disagreeably obvious. Based upon my experience, Kretol is not a promising insecticide.

Petroleum.—This was used altogether as a winter application on all the ordinary orchard fruit trees, with results that are elsewhere recorded. Three made-up petroleum combinations were also tested, with generally unsatisfactory results. Several hundred thousand trees were treated with the crude oil during the winter of 1900–1901, and it will not be long before the range of usefulness of this material is finally established.

Besides these specifically named, a few other soaps and special

combinations were tried, but the results are not satisfactory. Weather interference spoiled some of the tests, and, altogether, it is more just to let specific reference lie over until a fairer trial is possible.

Whale-Oil Soap.

This has not, for some reason, proved successful as a winter application against the San José scale in New Jersey; almost every one using it reported partial or total failure. One correspondent reports an orchard of plum trees, thoroughly sprayed during the winter and apparently well cleared in spring, to be so badly re-infested at harvest as to seriously impair the value of a heavy crop of fruit. The larvæ were swarming in such numbers as to make treatment, as soon as the fruit was off, an absolute necessity. But, *on the other hand*, there are not wanting reports of excellent results following persistent use.

For summer work the material is excellent, and I have used Good's *potash soap* with satisfactory results, against plant lice as well as scales. For plant lice, indeed, I know of nothing better. Its use, on a large scale, against the pea-louse, is elsewhere recorded. Against apple plant lice I found it effective in the experiment orchard, and reasonably so against grape leaf-hoppers.

Late in the season I sprayed several trees with about 1 pound in 2 gallons of water, to check San José scale breeding, with excellent effect. It cleared out all the active larvæ and many recent scales. It had no effect on older insects nor upon the breeders; but as this was not expected there was no disappointment. It did not harm foliage, even on peach. Altogether the material has proved so useful that a proper supply seems necessary on any farm where plant lice of any kind, or scale larvæ, must be fought.

An experiment made in Atlantic county shows that an application of 1 pound in 1 gallon of water, made September 21st, will kill the rose scale wherever it is brought into contact with it. At half that strength it is practically ineffective. The stronger mixture defoliated the plants; but, at that season, this merely hastened, without injury, the normal foliage. The buds, in all examined cases, remained sound.

Crude Petroleum.

This material is now the chief reliance for fighting the San José scale in New Jersey, and our farmers are learning gradually how best to use it.

On June 22d, Mr. W. P. Cutler, of the Atlantic Refining Company, informed me that they had sold 795 barrels of crude oil for spraying fruit trees in the State of New Jersey, during the winter months of 1900–1901. Over 100 barrels were sold by two other companies into this State, and there is no doubt that over 800 barrels were actually used by our farmers. A considerable quantity was also purchased from dealers who did not specify the purpose for which it was purchased, and of which, therefore, the selling companies had no specific record. This means, certainly, forty thousand (40,000) gallons of oil used, and, at an average of one pint per tree, large and small, diluted or undiluted, would mean three hundred and twenty thousand (320,000) trees sprayed! It will be quite safe to put the figure at 250,000.

It would seem as if this was a sufficient number upon which to base a fair judgment as to the value and effectiveness of crude oil. It would seem also that, if it were really dangerous, a large percentage of the treated trees should have been destroyed, or at least materially injured. Yet the reports that have come in from those that have used it certainly do not bear out the idea that any great harm was done.

One of the latest records comes from a prominent fruit grower in Gloucester county, dated October 10th. He used twenty barrels of crude oil, mostly on pear, though some peach trees were also treated, with very satisfactory results. The oil was used soon after the holidays, and was applied undiluted. Not a single tree was injured, and, at the date of writing, the trees were as green as in midsummer. The oil seemed to give them a new vigor. "Where we sprayed last winter we saw scarcely any scale, but where we sprayed a year ago last winter we had considerable scale on the fruit; so I have come to the conclusion that we will have to spray every two years. I am satisfied that we can control the scale, but will not get rid of it. I do not fear it as much as I do the Codling Moth, for we have to spray two or three times each year, and sometimes it will get the best of us." On this farm the oil has been used for three years, and up to this point has hurt nothing. Of course, the owner is a careful man. He realizes fully what he is doing, and the applications are made under his personal supervision. He is also a successful grower, who makes fruit growing pay; so his utterances are those of a practical man and not a theorist.

Results equal to this have been obtained by other fruit growers whose orchards I have seen, and of pear trees I do not believe a

single one has been injured. Apples have not been so fortunate. Some varieties seem to be quite susceptible to injury, and there are several records of trees severely injured, or even killed, where the application was made too liberally. Yet, as will appear later, some varieties will stand the most thorough application possible. On plums the applications seem to have been unusually satisfactory.

A Gloucester county plum grower sprayed all his trees with crude oil during the winter, and, in fact, has used the oil for two years. He harvested an immense crop of plums this year, all in the finest condition, and his report, late in August, was that: "Wherever the oil came in contact with the scale it is completely destroyed. I should have used a double nozzle, but, being timid, I used but one. The extra application I gave some of the trees has removed fear, but my experience has taught me to be more careful in covering fully."

The "Rural New Yorker," of June 29th, 1901, contains a report of applications made to Abundance, Satsuma and Bailey Japan plums, on the Rural Grounds, in March. The statement is that these trees have now the darkest and most luxuriant foliage of all. "We do not think the oil can add anything to the vigor of the trees; but the thorough applications we gave, going over every twig twice, have not only exterminated the scales, but surely must have buried beyond all resuscitation any fungous spores that adhere to the bark, as the surface is still coated with paraffine, which will remain, according to previous experiences, until late next spring." The suggestion is made that this application may really have had considerable effect as a fungicide, and may account for the generally-better condition of the sprayed trees, as compared with others of the same varieties that were not treated.

On September 4th, the same journal published a summary of two years' trial of crude petroleum. Eleven young fruit trees were cleared of scales, and remained clean for one season. In one case, scale appeared in midsummer, after a spraying in March. Eight trees were cleared of scale, and remained clean for two successive years. One tree remained clean one year, but showed re-infestation the second. "The failure to clear out scales the first season was in a good-sized Satsuma plum tree, headed back to get rid of small branches. The tree was sprayed carefully late in March, but damp and foggy weather evidently prevented the oil from sticking, and the June brood spread over the unprotected areas, but has not gained a foothold on the greasy surfaces." A good suggestion occurs at the end of the note: "The difficulty of thoroughly spraying large trees

is at once evident on trial, and the final outcome, unless totally new methods of relief are discovered, is likely to be a demand for low-growing and earlier-bearing varieties."

On peach trees the oil has been generally successful, but there is some complaint of injury. More peach tree treatments were made than ever before, not only in this State but also in Ohio. From the latter State I have general reports only, and they are favorable. In the Catawba Island district, 200 barrels were used of the high-grade oil, and some of a lower grade. It was used diluted and undiluted, and success is reported for both methods. A heavy oil was used in other sections, and seems to be favored by some when a 20 to 25 per cent. mixture is to be employed.

In Hunterdon county, Mr. Fred. B. Sutton, of New Germantown, did considerable commercial spraying—that is, he contracted to spray orchards for others who did not have the machinery, or who preferred to have the work done. In answer to my request for suggestions of a practical nature, based upon his experience, he writes as follows: "You ask, in yours of the 18th, what, in my opinion, are the proper rules to be observed in working the Kerowater pump. In the Deming and Fields Kerowater the only rule I would suggest is—not work them at all. Oil and water are so averse to mixing that an accurate per cent. of each cannot be coaxed out with one pump with two suction pipes and a valve on the oil suction. In the Goulds Kerowater the oil-tank holds, say, 6 gallons, and the water barrel around it, say, 45. If each is filled and the pump set to pump *over 12 per cent.* oil, the oil-tank should empty first. Anyone not acquainted with the result would likely pump so long as any oil comes out of the nozzle—then they shut off the cocks with more or less compressed air in the air chamber of each pump This is wrong. Pumping after oil gets below the suction in the oil-tank allows water to work over in the oil-pump or tank, and, when the valves are not perfectly tight in the oil-pump, the compressed air forces water from the larger pump and chamber until quite some water may be found in the oil-tank. Sometimes, too, the water compartment is filled to the top, and driving will splash a little more in. Then someone spills a little in when filling.

"No matter where it is put it in, it all goes to the bottom, and when it is started again, why, the darned old thing pumps all water. Of course, what else could it pump, when both suctions are in water, and the oil-pump being so much smaller and so far behind, is quite

a while catching up. It's got all that length of hose and extension to run, too."

"Now, in the first place, both pumps must be kept well fitted and on equal footing with each other, because one is working against the other, and if either slips it can't do its share. Then the pnmp should be stopped before the oil gets quite out, and the stop-cocks be left open, to let the compressed air out, so that the pumps will not be pushing against each other while filling. Then—don't fill the water-tank too full and the pumps will be much more to the people's liking."

In another communication, Mr. Sutton, in speaking of the work done in his vicinity, speaks as follows: "As to the results from spraying oil, I think most of the orchards sprayed have been improved, but many have had such poor work done that nothing was gained. The 25 per cent. spraying is, without doubt, showing hetter now than the undiluted applications, and most everyone here is favoring it. The other may last longer and be best; but I have seen more good on peach with 25 per cent. I think clear oil is too strong for the peach tree. Either, well done, will keep the scale in check, and that is all we may expect; but what is best for the tree? I think the March spraying is looking best, too, and there is more oil left to kill what was at first missed than where spraying was done earlier."

These suggestions are important and should be taken into consideration by those who find it necessary to use the oil.

The experience that I have gained has led me to change just a little my views on the desirability of undiluted applications. I still think that using the high-grade oil undiluted is best when the work is properly and intelligently done. It is in this way that I have used, and shall continue to use, it whenever I find it necessary. The average workman, however, is likely to lose sight of the importance of careful work at times, and under such conditions probably a 25 per cent. mixture would answer better. If this percentage only is used, it will also be possible to use a heavier oil, which may be cheaper. The heavier oil is, in fact, deemed better by some, because of the greater paraffine content; it leaves a thicker coating for a longer time. In other respects, I have no change to make in the suggestions as to using crude oil. Fruit growers are coming to use it with more confidence and better judgment, and machinery is becoming better adapted for the work. The Gould Kerowater is still the best American pump for spraying a mechanical mixture. A machine

made in London, Ontario, and called the "Spramotor," has been also tried by Ohio growers and by some in Canada. This, too, has proved to be satisfactory, and in some respects may be even better than the Gould pump. At all events, there are two good machines on the market, and, as the quality of the oil for the mechanical mixture is not so important, it may be safer to use this.

My own applications have been on the Experiment Orchard only, and all of them have been of oil undiluted. Only one record is here given. Tree 30 is a Grimes Golden Pippin. It had been sprayed in 1898, but received no treatment in 1899. In the latter part of that year a few scales found their way on the tree, and during 1900 it became very badly infested indeed. The bark when cut showed the bast evenly purplish-red, absolutely unhealthy, and the red stain extended into the wood. I do not think I ever saw a much worse-infested tree than this was when winter finally set in and the scales stopped breeding. I determined, therefore, to give the most excessive treatment possible, to test the effect of oil in large quantity upon a tree weakened by scale attack. During the first days of January I spent two hours painting the tree from the tip to the surface of the ground. The oil was applied with a brush, by holding it to the end of a twig and simply letting it run down. The top of the tree was reached from an eight-foot ladder, and it was necessary to bend down the longest shoots. In this way every part of the tree received as much oil as would possibly stay on it. It was allowed simply to run down from the tips. The crotches had a very heavy application, and so did the larger branches, which received oil from all the smaller ones coming from it. The trunk was treated in the same way, and the oil allowed to run as far as it would extend underground. By the middle of January I concluded I had done for the tree completely. The oil was of the 45° material that I brought with me from West Virginia. The greasy coating over the surface was dense, and whenever there was any moisture in the air the tree presented a curious sight, owing to the globules of water standing over its entire surface. On cutting some of the shoots it seemed as if the oil and the stain from the scale had united to simply soak the wood. It was wet clear through, soggy, and looked as if bound to die. Wherever I tried the knife the appearance was the same, and I concluded that I had done the trick this time without any doubt. But as spring approached the tree seemed to improve in appearance; a few twigs did shrivel up and die, but the others began to plump out. When I pruned the

orchard I cut this tree back a little more, in some directions, than I would ordinarily have done—but, on the other hand, allowed a great many more small shoots to stand in the center. Much to my surprise the tree started—though a little later than normal—not only started but grew and grew well, and has continued to grow throughout the season. There was absolutely no loss in the tree of anything that should have remained, and during the entire season not a scale was to be seen anywhere on it. Traces of the oil remained until October, and some parts of the trunk still had then a vaseline deposit that could be scraped with the fingers. Soon after growth commenced the coating of scale began to flake off, and in October most of the branches were absolutely clean and fresh-looking. I do not think it would have been possible to put more oil than I did on this tree—no more would remain on—and if any oil application could kill this tree it should certainly be dead by this time.

It was suggested, in a previous report on this subject, that possibly a made-up material, consisting of the light oils and paraffine without any vaseline, might make a better material than the whole oil. Some of the Ohio growers induced the Sun Oil Company, of Toledo, Ohio, to make up some samples, and of these I received four specimens. No. 1, a straight crude, sp. gr. 44.5°, was a very light amber oil, with a very pungent odor of naphtha. No. 2, marked partly refined, sp. gr. 44.5°, was said to have the vaseline and burning oils out and to retain the naphthas and paraffine. This was the thinnest of the mixtures and spread better than the undiluted crude. It instantly soaked everything that it touched. No. 3 was the same as No. 2, but heavier, the sp. gr. being 41.5°. It was also very fluid at a moderate temperature; but, in the cup, formed a surface film before I was through, and a surface film also formed in the can. No. 4 was yet heavier, having a sp. gr. of 38.5°. This spread less rapidly than any other, and thickened quickly on exposure to the air; in fact, what was left in the cup was so thick that it would not pour back into the can, but had to be taken out with the brush. The application was made February 11th, on a bright, clear day—sunny and warm—in the sun. There was snow on the ground, and in the sunshine this was thawing; no wind. Trees 1, 28 and 29, representing plum, peach and apple were used for the experiment, and each tree had one branch painted with each of the samples. In other words, four branches on each tree were treated, each with a different mixture, and all were tagged. Next day I found that sample No. 2 had extended down a considerable

distance below the point reached by the brush. On tree 28 it had reached down the trunk fully 15 inches, and for a space of four inches had soaked all around the trunk. This sample has much the greatest spreading power. The undiluted crude was greasier in appearance than any of the others, and sample No. 4 had the dullest appearance. Sample 2 was driest of all; but even here a greasy mark was produced on rubbing.

The net result of this experiment was that samples 3 and 4 killed the branches to which they were applied. Sample 2 did some injury, and sample 1 did no harm at all. The applications were all alike in quantity. Sample 4 could not be used in weather that reached the freezing point; in fact, it is doubtful whether it could be used with the thermometer at 40°. Sample 3 was better and could probably be used at the latter temperature. Sample 2 could probably be used whenever the crude oil itself could be employed; but I do not find that it would be as safe.

It is not deemed necessary to collate results obtained by other experimenters in other parts of the country; some are good and some are bad. Some find the undiluted oil harmful, but the 20 per cent. mixture both safe and effective. For the conditions as they exist in New Jersey I consider the crude petroleum much the best material for use against the pernicious scale. If used undiluted, a high-grade oil and intelligent care are necessary in making the application. If used in a mechanical mixture, a lower-grade oil may be used, and 20 per cent will be sufficient. In this case, the spray pump must be watched to get uniform results, and the suggestions made by Mr. Sutton should be followed.

As to the time of making the application, it seems indicated that it should be delayed until after midwinter. The ideal period for spraying is just when the sap begins to rise; but as there may be a week of unsuitable weather at that time, it is best to begin earlier. Late February in South Jersey and the middle of March in the northern counties would probably be nearly right as beginning dates. In all cases wait until after January 1st.

NEW BENEFICIAL INSECTS.

In the June, 1898, number of the "Entomological News," published by the American Entomological Society in Philadelphia, Mr. Philip Laurent recorded the capture, near Germantown, Pennsylvania, of a large and striking Chinese insect, belonging to the Raptorial

family of the *Orthoptera*, or straight-winged insects. The specimen came from the Meehan nurseries, and was accepted as an accidental importation—which it undoubtedly was. In the year following more were found, and in the winter egg masses were seen on twigs, indicating that the insect had become established and was breeding. Plate iii., herewith given, is a duplication of Plate IX., Ent. News, Vol. IX., and gives a fair representation of the insect, about natural size.

The family *Mantidæ* is of small extent in the order which contains such pests as roaches, grasshoppers, crickets and the like, and differs from all its fellows in that it is predatory and carnivorous in its habits, feeding upon a great variety of other insects. Not only this, but the individuals are extremely voracious, requiring a relatively enormous amouut of food to bring them to maturity. The occurrence, then, of this Chinese species, at Germantown, Philadelphia, was matter for congratulation, rather than otherwise. There is no reasonable doubt that an egg mass, coming on or with a shipment of Asiatic plants to the nursery, escaped notice, and hatched out specimens that found themselves able to survive.

I had kept rather a close watch on the species since its presence was first reported, and, when it seemed certain that it was really domesticated, I asked Mr. Laurent to secure for me, during the winter of 1900–1901, a number of the egg masses for introduction into New Jersey. He very kindly agreed, and sent about 150 of them early in May. These were divided into six approximately equal parts, and distributed, one part each, to Mr. John Repp, Glassboro; Mr. J. Lawrence Lippincott, Riverton; Mr. Horace Roberts, Moorestown; Mr. N. P. Creeley, Burlington, and Mr. Henry Pfeiffer, Cologne. The sixth lot was retained by myself. All the gentlemen referred to acknowledged receipt of the sendings, and declared that they had complied with the terms of my request. Mr. John Repp placed them on apple, pear, cherry and currant, tying on the masses in accordance with directions, as, indeed, did all the others herein referred to.

Mr. Roberts distributed the clusters, somewhat widely, on a variety of orchard and small fruits; Mr. Creeley put them on currant, gooseberry, cherry, quince, pear and apple trees; Mr. Lippincott tied them on trees in a row across the orchard (apple and pear), and Mr. Pfeiffer put them on apple, pear, peach, plum, currant and strawberry. The lot retained by myself went, mostly, into the experiment

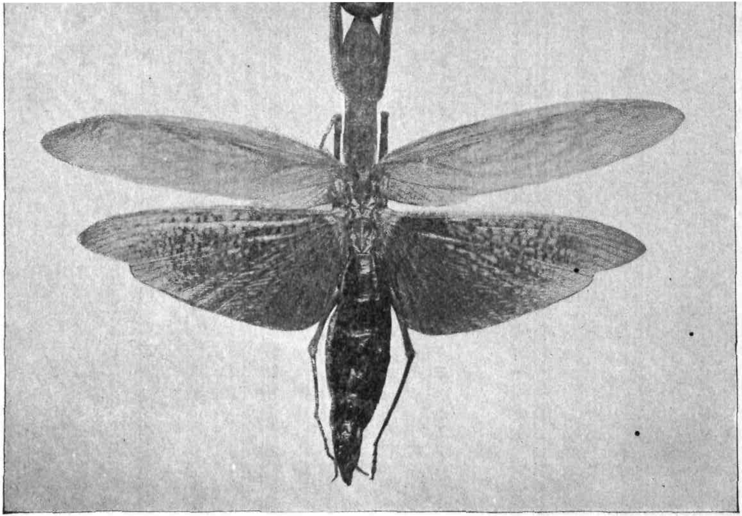


Fig. 3.

Tenodera sinensis S us. ; adult female. (From Laurent Ent. News, vol. IX., pl. IX.)

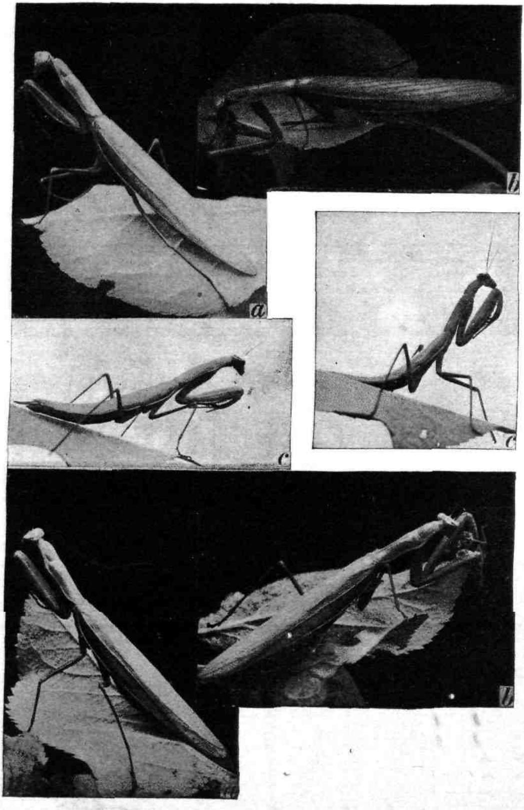


Fig. 4.

The praying Mantis (***Mantis religiosa***), ***aa***, adult in waiting position, watching for its prey; ***bb***, adults eating grasshoppers; *cc*, larval forms awaiting prey; all natural size. (From Slingerland, Bull. 185, Cornell Exper. Sta.)

orchard, though some were tried on the fruit trees of a neighbor's garden.

In November, 1900, Prof. M. V. Slingerland, Entomologist to the Cornell Experiment Station, published Bulletin No. 185, containing an account of the European "Praying Mantis"—*Mantis religiosa* Linn—which had become established in the vicinity of Rochester, New York. It seems to have made itself fully at home there, and Mr. Slingerland kindly secured for me a lot of egg masses, that I might attempt to establish the insect in New Jersey. Unfortunately, a large proportion of these masses were not sound, and contained dead eggs only. Some were, apparently, of the previous season, and the eggs were empty ; others contained parasites, or predatory forms, and these were destroyed at once. The balance was divided into three small lots, of which one went to Riverton, a second to the College Farm, and the third was distributed in the Experiment Orchard. The illustrations of this species are from the New York Bulletin, above cited.

The Result.

All the gentlemen receiving eggs, of either species, report that they have seen nothing resembling insects such as I described to them ; but the egg masses returned to me contained empty shells only.

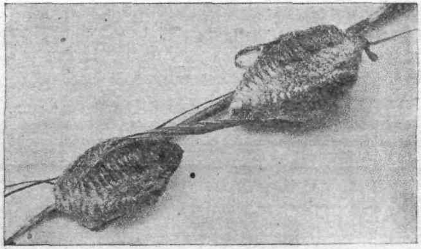


Fig. 5.
Egg cases of *Mantis religiosa* on grass, from Rochester, N. Y.
(From Slingerland, Bull. 185, Cornell Exper. Sta.)

In my own garden I saw immature examples on several occasions during the summer, and late in August a fully-developed female of *Tenodera sinensis* was captured in a neighbor's garden, and its life was

begged from the neighbor's boy. A second example was captured late in September, and also released. It is probable that the immature forms seen were of the same species as the adult; but, as they were not captured, and slipped out of sight between the leaves of a grapevine, this cannot be certainly declared.

It is not improbable that though none of the insects have been noted at the other points where eggs were placed, they have yet established themselves, and may make themselves more obvious next season. The effort to domesticate them in the State will be continued if egg masses can be obtained.*

Results Aimed At.

The general object to be gained is the addition of an effective ally to the rather scant army of predatory insects found in our State; or, better, to the predatory types, able to feed on injurious species. These Mantids are creatures of that type; they are always hungry, and find a congenial home in gardens and orchards, devouring everything that crosses their path, that is not capable of devouring them. As they are over two inches in length when mature, not many insects, if any, can master them.

No possible harm will result, so far as can be foreseen, for no sort of vegetation is eaten. No ally is threatened seriously, and, though no direct observations have been made, there is some hope that in the earlier stages they may feed on scale insects.

More specific information concerning the life history and habits of these species may be deferred until their establishment is made certain.

A Natural Introduction.

During the early part of October a male specimen of the *Tenodera* was received from Mr. Hiram T. Jones, of Elizabeth, and this may be either an original importation on stock from Japan, as Mr. Jones believes, or may have come from some stock received indirectly from Mr. Meehan two or three years ago. If the latter, there is a chance that the insect will be found in Ohio in the near future, because the stock suspected of bringing it in came through that State.

* During the winter of 1901–'02 several egg masses were found in and near the Experiment Orchard—one about 1,000 feet away; so there was not only a survival, but a reproduction.

MISCELLANEOUS.

The correspondence of the office during the year 1901 is contained on 1,935 pages of letter-book, representing above 2,500 separate communications; and this does not include the circular letters sent to nurserymen, commissioners or secretaries of the boards of health within this State.

Seven institute meetings were attended and five county board or other meetings, for each of which an address on some entomological topic was prepared. A report was made to the State Board of Agriculture of the work done as State Entomologist, and an illustrated lecture was delivered at its annual meeting, detailing some of the results of my trip to European institutions.

Bulletin No. 147, on "The Angoumois Grain-Moth," and No. 149, on "Two Strawberry Pests," were issued since the last report, and have been distributed. A circular was prepared warning fruit growers of the probable appearance of a brood of the Periodical Cicada in 1902, and this was sent out with Bulletin No. 153. An index to the popular names used in the list of insects found in New Jersey was prepared for and published by the State Board of Agriculture, and this, it is believed, will increase the general usefulness of the work.

I have continued my attendance at the meetings of the Entomological Societies at Newark, Philadelphia, Brooklyn and New York, and have received from the members assistance in the form of specimens and information whenever desired. I consider it an advantage to be in touch with so many working Entomologists and collectors, and it gives me unusual resources in securing reliable information and material from a number of points. Credit is specifically given for individual contributions wherever they occur.

Acknowledgment is also due to Dr. L. O. Howard and his staff of assistants at the United States Department of Agriculture and United States National Museum for information and other courtesies.

State Entomologist.—The work done in my capacity as State Entomologist has supplemented the work of my department in the Stations and has been almost altogether in the line of controlling the commercial spread of injurious insects. The San José scale was mainly aimed at, but the work has really resulted in the destruction or check of quite a number of other species.

Nurseries are now under control, and it is believed that stock more free from living insect pests than that which most of our nurserymen

send out will be difficult to find. A closer supervision than ever before is exercised by the nurseryman himself, which ensures the receipt by him of clean stock and the sending out of similar material to the purchaser. Inspection of infested orchards was made at the request of individuals and advice was given to suit existing conditions. In fact, the general line of work was the same as in the year previous.

The Collection.—The collection of the department has grown continuously and much of the material has been put into permanent shape during the past year. Several cases illustrating the work of forest insects are made up from specimens sent in by Mr. J. Turner Brakeley from Lahaway, Ocean county, during a period extending over two or three years. Some of this is unique in character and unequaled in extent. An abundance of other material yet awaits arrangement, and fifty drawer cases were added during the year for that purpose.

The special collection of the late Dr. George D. Hulst, of Brooklyn, N. Y., is now also in charge of this department, and has been partially arranged. This is an exceedingly valuable addition, representing, as it does, the life-work of the donor and containing many of the original types of the species named by him.

Assistance.—During most of the year I have had the assistance of Mr. E. L. Dickerson, Class of 1902 S., for such periods as he could spare from his studies. During the summer he spent the entire months of July and August with me, and was of material assistance in the office work. He did also some of the preliminary inspection work in orchards and nurseries, materially facilitating my later work.

Pan-American Exhibit.—The department, as such, was not represented at the Buffalo Exposition; but some 30 cases, illustrating injurious insects and their work, formed part of the exhibits of the State Board of Agriculture and of the Forestry Exhibit of the State Museum. These cases were prepared at the request of Mr. Silas R. Morse, Curator of the Museum, and were used to illustrate the two exhibits above mentioned. It was the object, in arranging these cases, to illustrate all stages as well as the injury caused, and some of them represent several years of study and collecting. They are now accessible to the general public in the halls of the State Museum.*

Haseltine's Insect Trap.—This is a large and deep tin pan, in the center of which is fixed a lamp, or torch, the light from which is reflected by two tin sheets crossed at right angles in the center. The

* *Gold medals were awarded to these collections.*

pan is filled with water, which is covered with a scum of oil, and into this the insects fall when attracted by the light. For certain purposes the device may be a good one; but so sweeping and wild are the claims made for the contrivance, and so reprehensible and dishonest the methods of the persons advertising it, that it seems well to caution intending purchasers not to expect too much from it.

Many insects are readily attracted to light. For others it has no attraction whatever. Among the forms attracted are some injurious and some beneficial or useful forms. Among the forms not attracted are the great majority of all species, including some of the most injurious. Insects of the first series will be undoubtedly caught, to some extent, by the traps; others will not. To rely upon the trap alone, in an orchard, would be suicidal, for the plum curculio and the codling moth do not, either of them, come to light at all freely. I have no doubt the trap will show up hundreds of insects, at favorable times, but at least half of these will be predatory, parasitic or innoxious forms, which are better alive than dead.

INSECTS IN THE CROP BULLETIN.

The *San José Scale* has the honor of being the first species referred to in the Crop Bulletin of April 30th—the first issue of the season. It was reported as doing great damage to fruit trees, particularly peach, at Franklin Park, Middlesex county, and much spraying with crude oil was done. At Hammonton, Atlantic county, many peaches were reported as having been killed by the scale. June 4th, some scale was noted on pear at Trenton Junction, Mercer county. June 11th, I made use of the Bulletin to advise growers to be in readiness for summer work as soon as breeding should be observed, and this seems to have had the effect of shutting off complaints; at all events, nothing further was heard of it.

Tent Caterpillars were first noted May 14th, at Rowlands Mills, Hunterdon county, in small numbers. June 11th, they were numerous at Kingwood, Hunterdon county; June 18th, the same report came from Ocean View, Cape May county; July 9th, they were marked unusually troublesome at Hazlet, Monmouth county, and I suspect that at this time the "tent caterpillar" was really the fall webworm, to which all further records under this general head must be referred. At Burlington, Burlington county, they were so numerous that growers were "compelled to stop harvest and spray to check their ravages;" July 16th, they were so numerous as to cause grapes

to fall off; July 23d, they were again reported, and on the 30th Egg Harbor City, Atlantic county, took up the refrain. August 27th, Rahway, Union county, reports apple trees infested with the insects, and Rancocas, Burlington county, reports their presence without comment. September 3d, the insects were reported from Freehold, Monmouth county; Kingwood, Hunterdon county; Trenton, Mercer county, where they also attacked vegetables, and Lakewood, Ocean county. September 10th, they attracted attention at South Orange, Essex county; New Brunswick, Middlesex county; Cranford, Union county; Kingston, Somerset county; Pittstown, Hunterdon county; Cape May Court House and Cape May City, Cape May county; Deerfield township, Cumberland county, and Egg Harbor City, Atlantic county.

The pest was thus recorded throughout the State and really deserved all the notice it received.

Cut-worms were first noted at Mantua, Gloucester county, May 14th, and the week following they were numerous at Woodbury. May 28th, they were reported from Middlebush, Somerset county, and Fishing Creek, Cape May county. June 11th, Pottersville, Hunterdon county, reported them as injurious enough to make replanting of corn necessary, and Trenton Junction, Mercer county, reports them as numerous.

The first report on the *Colorado Potato Beetle* was May 21st, and was encouraging; Cranbury, Middlesex county, recording it not so numerous as usual; but this was not so of Woodbury, Camden county. May 28th, the insect was reported from Paterson, Passaic county; Cassville, Ocean county, and Woodstown, Salem county—at the latter point less numerous than usual. June 11th, the insects were numerous at Kingwood and Sergeantsville, Hunterdon county; at South Bound Brook, Somerset county, they were destructive to newly-set tomato and eggplants, and shared with the squash-bug the honor of a report from Fishing Creek, Cape May county. June 18th, the beetles were troublesome at Cranford, Union county, but, apparently, nowhere else. June 28th, they were "numerous" at Huntsburg, Sussex county, and "destructive" at Lincoln Park, Morris county; Layton, Sussex county; Frenchtown, Hunterdon county; South River, Middlesex county; Salem, Salem county, and Shiloh, Cumberland county—at the latter point tomatoes are included in the injury. July 2d, they caused much damage at Frenchtown, Hunterdon county, and, on the 23d, injury was caused at Huntsburg, in the same region.

The *Strawberry Weevil* was reported as injurious once only, May 21st, from Deerfield township, Cumberland county.

The *Plum Curculio* was first referred to May 21st, from Moorestown, Burlington county, and then as not so bad as usual. June 4th, it, on the other hand, was reported as injuring much fruit at Mickleton, Gloucester county.

Plant Lice held their own well, as injurious forms. The first complaint came from Mickleton, Gloucester county, and was of the species infesting cabbage. This seems to be the only record of this species, though, on August 20th, Seargentsville reports what is probably the same species on turnips and radishes.

Lice on apple trees were noted June 4th, at Mickleton, Gloucester county, in numbers sufficient to endanger the crop. June 18th, they were reported from Hazlet, Monmouth county, and covered the trees at Rahway, Union county. June 25th, they caused the dropping of fruit at Middleville, Sussex county, and at Elizabeth, Union county, were troublesome. July 2d, fruit was dropping badly, and trees were infested by lice at Hanover, Morris county.

Cherry trees were unusually infested, the first report coming June 18th, from Newton, Sussex county, where they caused fruit to drop; and they were also numerous at Hazlet, Monmouth county. June 25th, Millington, Morris county, reports that "cherries do not mature, being covered with lice," and Middleville, Sussex county, reports the fruit dropping from the same cause.

Lice on peach trees were reported June 4th, from Cape May Court House, Cape May county, and June 25th, from Plainfield, Union county.

Infestation of fruit trees, in general, is reported from Plainfield, Union county, June 11th.

The *Pea Louse* was first noted June 11th, at Cape May City, Cape May county. June 25th, late peas were infested at Mickleton, Gloucester county, and July 2d it was again reported "destructive" from the same point. July 9th, "many acres of peas ruined by lice," comes from Fishing Creek, Cape May county.

Potato Lice were reported once only, July 2d, from West Freehold, Monmouth county.

Melon Lice were noted on citrons, July 2d, at Mickleton, Gloucester county. July 30th, they were "very numerous" at Beesley's Point, Cape May county, and August 13th had "practically destroyed" some fields of cantaloupes at Mickleton, Gloucester county. August 27th, "Aphids destroying all vine truck" is the discouraging report

from Mount Holly, Burlington county, and this marks the end of that season.

The *Fly in wheat* is first noted May 28th, from Medford, Burlington county, though incidentally, and the Angoumois grain moth is first referred to June 25th, as appearing in wheat fields at Titusville, Mercer county. Injury by the "weevil" is reported July 9th from Kingwood, Hunterdon county, and on the 16th, both "fly" and "weevil" are noted at Frenchtown, Hunterdon county. August 16th, the "fly" was troublesome at Somerville, Somerset county. The Angoumois grain moth was noted September 10th from Middlebush, Somerset county; was doing much damage to stacked wheat at Sergeantsville, Hunterdon county; considerably effected wheat at New Egypt, Ocean county, and badly infested wheat at Shiloh, in Cumberland county. September 10th, the moth was reported in wheat from Rowlands Mills, Hunterdon county, and Mickleton, Gloucester county, states that "owing to prevalence of Angoumois moth less wheat will be sown."

Squash-bugs were numerous at Fishing Creek, Cape May county, June 11th, but were not again reported.

Currant-worms attracted attention at Frenchtown, Hunterdon county, June 25th, and on the same date the *sweet potato flea* was doing considerable damage at Salem, Salem county, some fields being destroyed.

Codling-moth was noted July 16th, at Deerfield, Cumberland county, and on the same day "small and wormy" apples were reported from Ocean View, Cape May county.

Corn or *boll-worms* became troublesome in cornfields, Cape May Court House, Cape May county, July 23d, but seem not to have become noticeably abundant elsewhere.

Tomato-worms, or "horn-worms," attracted attention July 30th, destroying some fields at Fishing Creek, Cape May county. At Kingwood, Hunterdon county, they were troublesome August 13th, and were again referred to on the 20th.

Cabbage-worms were numerous or destructive, August 27th, at Landisville, Atlantic county; Metuchen, Middlesex county, and Salem, Salem county.

Large Caterpillars, destroying the leaves of many plants, appeared at South Orange, Essex county, July 23d.

The "*Army-worm*" in millet fields became injurious at Fishing Creek, Cape May county, September 3d, winding up a season in which insects had been unusually varied in kind and character of injury

CRANBERRY KATYDIDS AND GRASSHOPPERS.

The locust plague often becomes serious in South Africa, and destructive swarms appear in some portions of that continent almost every year. The species there in fault is one of the *Acridiidæ*, or short-horned grasshoppers, and is an ally of our "bird locust," *Schistocerca americana*.

The insects fly in immense swarms from their breeding places, sometimes covering an area several miles in extent, and on it devour every green thing. Similar "locust" plagues are not unknown in our Western States, and for a time it seemed as though we were helpless when opposed to them. It was noted in Africa that sometimes the swarms were ravaged by an epidemic disease, and that individuals died off in great numbers. It was also found that sick individuals, brought into a mass of healthy ones, infected them with the same disease—hence it was determined to test the possibility of propagating it artificially. Pure cultures were obtained, and it was found feasible to introduce the disease into previously healthy swarms. Good success has been reported from Cape Colony in practical workings with this disease, but I have no details enabling me to judge the conditions required to enable it to reach its maximum effect. The idea of fighting insects with diseases is fascinating, and appears again and again as a serious attempt or an idle suggestion. Some attempts have met with a considerable measure of success, but always it has been found that success depended upon some definite combination of weather conditions and insect abundance. In the fight against the cinch-bug, in some of our Western States, it was found that in a drought, when the insects were most abundant, the disease was least effective. When weather and other conditions are favorable epidemic diseases are apt to flourish whether artificially introduced or not. During the season of 1901 thousands of the caterpillars that were so unusually abundant were carried off by a disease that left their dead and dry or pasty bodies everywhere on trees, trunks and fences. I always look upon an attempt to use natural agencies in an unnatural way as uncertain, to say the least, unless we can also furnish the surroundings needed for their effective action. In other words, epidemic diseases may sweep out of existence great multitudes of insects when circumstances favor their development, but they may lie dormant for years before such circumstances arise. In New Jersey a disease each fall carries off a considerable number of our common Carolina grasshoppers, but it has never been epidemic, and cannot easily become so,

because the insects are not sufficiently numerous to bring them into close contact with each other.

Grasshoppers are charged with causing much injury to cranberries each year, and katydids actually do cause serious annual loss on some bogs.

Mr. Joseph J. White, of New Lisbon, is one of the sufferers from katydids, and it occurred to him, after reading of the South African experiments and their good results, that possibly the disease might be equally effective on our bog species of short-horns, or even on katydids. He therefore communicated with South Africa, arranged for a supply of cultures, and turned the matter over to one of his daughters, Miss Elizabeth C. White, who kindly gave me the following account of her doings:

"A supply of locust fungus was ordered to be sent in several installments, about a week apart, to insure one or two, at least, being received. The first was mailed March 1st, by Alexander Edington, M.B., Director of the 'Bacteriological Institute,' Graham's Town, Cape of Good Hope, and was received by Joseph J. White, New Lisbon, N. J., about the first of April. Three other consignments were sent and received about a week apart, making in all sixty (60) tubes of the fungus.

"About the first week of June a few short-horned grasshoppers were found in bushy corners not reached by the water in the winter flooding of the bogs. These were dipped in a culture made from one or two tubes of the fungus, according to the directions. About a week or ten days later three or four more tubes were made up, and such hoppers as could be found were dipped. These were all, or nearly all, of the short-horned varieties. In the last days of June, many small, long-horned hoppers were found in a young bog where short, soft water-grass was plentiful. Hundreds of these were caught and dipped in a freshly-prepared culture of the fungus. The dipping was repeated about a week or ten days apart through July, about six tubes of fungus being made up at a time. No special effort was made at this time to catch katydids. The majority of insects dipped were the long-horned grasshoppers, but a few—two or three—of the katydids generally came in for a dipping at each culture of the fungus. I think the first one was caught about the last of the first, or the beginning of the second, week in July. Its wings were mere rudiments.

"There was no apparent result from any of these dippings, and, being under the impression that the long-horned meadow grass-

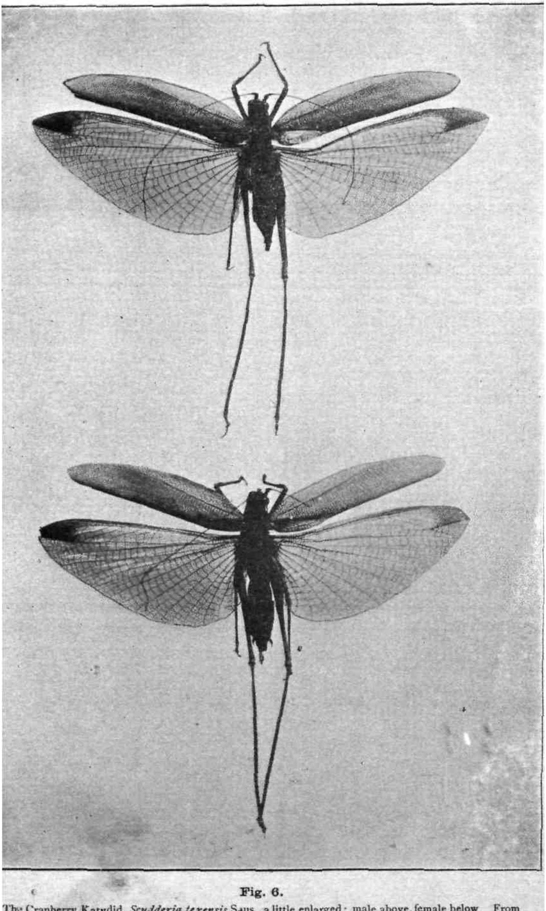


Fig. 6.

The Cranberry Katydid, *Scudderia texensis* Saus., a little enlarged; male above, female below. From an original photo.

hoppers were the mischief makers, we tried feeding them in cages, and I have the following record :

"July 23d—Fungus culture set about noon.

"July 25th—The culture seeming well grown ; grasshoppers were caught in a meadow, where they were apparently feeding on the seeds of red-top grass, and about twenty were put in each of these gauze bags.

"First bag—Hoppers with bunch of red-top.

"Second bag—Hoppers dipped in culture, with bunch of red-top.

"Third bag—Hoppers with bunch of red-top dipped in culture.

"July 26th—All hoppers in all bags seem comfortable.

"July 27th—Two dipped hoppers and one fed hopper dead ; the grass in all the bags sprinkled.

"July 28th and 29th—The grass sprinkled ; no apparent change in hoppers.

"The daily sprinkling of the grass was continued for several days, but all the grasshoppers continued in good health.

"This brought us to the end of our private resources, and we sent to New Brunswick for help. The experiment of feeding katydids with bran, of which the notes follow, was under the direction of Professor John B. Smith.

"August 21st—Mixed three quarts of fungus culture with about five quarts cooled boiled water, and thickened the mixture with bran till the bran did not drip. Spread most of the bran at the sides of Haddon Hall Centennial bog and across the top of the early Black bog.

"Caught thirty-one (31) katydids—18 males and 13 females. Sent three females to Prof. Smith, and confined the rest in two bags, evenly divided as to numbers and sexes. In each bag placed a small dish of the bran mixture, and in one (No. 2) a bunch of cranberries in addition. In a very few minutes a male began to eat greedily of the bran in bag No. 2, and soon a male and female were eating in bag No. 1.

"August 22d—Bran eaten in both bags, but most in No. 1. Through the day a lot of berries eaten.

"August 23d—Three females dead in No. 1 and one male in No. 2, in morning ; bodies eaten by other katies. At noon, two more dead in No. 1 ; more berries eaten in No. 2.

"August 25th—One katy dead in No. 2.

"August 26th—Three more katies dead in No. 1.

"August 28th—Two more katies dead in No. 1.

"This finishes the daily notes, but the insects were kept in the cages two or three days more, when all in bag No. 1 were dead."

Mr. White wrote me early in August, and I responded immediately, asking for a tube of the culture and a copy of the directions for use. August 13th, I received four tubes. The culture was in the form of a dark brown, long-drawn drop of tough, gelatinous matter, partly adherent to the tube, and at such points with a small, cottony growth or substance. The free surface of the gelatinous string was clean in all cases. The directions were in the form of a printed circular, of which the following is a copy:

LOCUST DISEASE FUNGUS.

Small tubes containing this fungus are prepared at this Institute and supplied to all applicants, who may also obtain them by application through the Civil Commissioner of their Division.

The methods mentioned below should be followed, and the result carefully watched and reported to me.

Highly satisfactory results have hitherto been obtained, and it is particularly requested that all persons using the fungus will report the result of their experiments to this Institute.

During dry weather it is difficult to get the disease to spread, and hence it is advisable to use it in moist, wet weather, and to make the infections of the swarms just before sunset.

DIRECTIONS FOR PREPARING THE FUNGUS PREVIOUS TO USE.

Open a tube and take out the contents entire; add it to two teaspoonfuls of sugar and rub the whole together with a spoon or flat knife, so as to break up the material and mix it thoroughly. Then dissolve this in three-quarters of a tumbler of water, which has previously been boiled and allowed to cool. Float in this a few pieces of cork, which have been previously steeped in boiling water and cooled

Now cover the tumbler with a piece of paper, and let it stand during the day in a warm corner of the house, or until the fungus is seen to be growing around the pieces of cork.

METHOD OF DISTRIBUTION.

(1) Catch some locusts, and, after dipping them into the fungus, let them go into the swarm again.

(2) Smear patches of damp ground, where the locusts alight to feed, with the fungus.

(3) Confine some locusts in a box which contains some favourite food moistened with the fungus, and, after the food has been eaten, return the locusts to the swarm.

(4) Collect a large number of locusts which have died from the fungus. Dig a hole in the ground about eighteen inches deep and one foot wide.

Strew some locusts over the bottom, then sprinkle some water over them. Repeat with locusts and again sprinkle until the hole is full. Do not press the locusts into the hole, but leave them lightly packed. Then cover over with a piece of tin or

board, and keep the hole thus carefully covered for four or five days. If very warm weather four days will be sufficient, but if colder a longer time will be required.

At the end of this time remove the locusts and spread them out in the sun for an hour or two or until thoroughly dry. Now grind them into meal.

Of this meal, which may be kept dry for a long time until wanted, take two tablespoonfuls and add it to a large tumberful of water, into which some sugar has been placed. Leave this in a warm place for twelve to forty-eight hours, and then treat live locusts by dipping, etc., just as one does in using the fungus when supplied in tubes.

METHOD OF APPLICATION FOR VŒTGANGERS.*

Take about one pound of white bread; dry it, and then grate it down to coarse powder. Put a cupful into a bowl and add enough water to make a watery paste. Add to this the contents of one tube of fungus, and keep it in a warm place until the fungus is seen to be growing over it. Now, place small portions where the vœtgangers are appearing, and take care to see that where not eaten up the small portions are kept moist from day to day until they have been eaten.

ALEXANDER EDINGTON, M. B.,
Director Bacteriological Institute,
Graham's Town.

February 19th, 1899.

The first lot was prepared August 14th, directions being closely followed. The culture was cut and carefully broken up with the sugar into small fragments. Water was freshly boiled, cooled to scarcely lukewarm, and then added to the sugar and culture. Bits of cork were also boiled and floated in the mixture while yet a little warm. It was then poured into a beaker, covered with cardboard, and left undisturbed until August 18th, when it was poured into a bottle and carried to New Lisbon, to be employed on the bogs on the 19th. This was No. 1.

The other tubes were prepared August 15tb, and the culture, having been cut into very small pieces, was ground with the sugar in a clean mortar and thoroughly broken up. Used for one lot, boiled water thoroughly cooled and placed in a covered tumbler. This was No. 2. The next lot was prepared as before, but put into a wide-mouthed bottle, which was corked and marked No. 3.

The last lot was prepared with unboiled, distilled water from the Chemical Laboratory—but the bits of cork were boiled before being added to the mixture. This was No. 4.

August 16th—Culture No. 1 showed signs of a fermentative growth, and the entire mass was turbid, with a streaky admixture. Of the others, culture No. 2 showed only little signs of growth ; culture No. 3 showed evident signs of growth in the mass, and culture No. 4 remained almost clear.

*Vœtgangers—Foot-goers : the local term applied to the larvæ or wingless forms.

August 18th—The corks in all the cultures began to show a growth at the edges, and the liquid was somewhat opaque and streaky. In the late afternoon all were put into four-ounce bottles, tightly corked and packed for transportation. The conditions had been favorable for growth, the temperature being close to 80° at all times and atmosphere humid.

August 19th—Reached the bog at about 10:30 A.M., and with the assistance of Miss White, captured a large number of *Orthoptera*, which were thoroughly dipped and released. Altogether treated about twenty-five katydids, half a dozen *Conocephalus*, over one hundred meadow grasshoppers, *Orchelimum* and *Xiphidium*, and over one hundred *Acridiids* or short-horned grasshoppers, *Melanoplus*, *Paroxya* and *Acridium*. The conditions for the disease were favorable, as it was very hot and sultry. The bogs also were very wet, and I sprinkled what remained of bottle No. 2, after dipping, over an attractive patch of berries.

Only one bottle of the culture was used in this way. It was realized that the katydids, which were the main objectives, were so scattered that the idea of starting an epidemic, based on contract of individuals, was a hopeless one. The truth is, the *number* of katydids is not so large; but their voracity is so great and their life period so long that the injury caused is altogether out of proportion to their abundance. A single individual will often eat the seeds from four to six berries at a single meal. As they live on the bogs over a month, 150 berries for a single insect is not an extravagant estimate. *Conocephalus* and *Orchelimum* probably assist materially in the work of destruction, but they are also somewhat rare, and only *Xiphidium*, of all the long-horned grasshoppers, is really plentiful. If these ate cranberries no fruit could remain on the bog, because sometimes, in a grassy area, the insects are as abundant as the berries themselves.

After looking over the subject carefully, it was deemed wiser to try to spread the infection, if possible, through the food, and the bran mixture was recommended. Miss White has reported upon what she did.

It remains to add that she sent me some of the dead katydids referred to, and that in no case was there reasonable cause, after microscopic study, for believing that the death was due to this specific disease.

Of the bran spread on the bogs, some was apparently eaten, but no results were noted in a decreased number of *Orthoptera* of any kind. The experiment was a failure, and not unreasonably so. The

disease spreads naturally in the great swarms of short-horned grasshoppers where one individual is in frequent contact or touch with its neighbors. It has no chance against scattered specimens, and may not even be fatal to the *Locustidæ*—long-horned grasshoppers and katydids—under the best of conditions.

It should be said in this connection that, in a recent publication from the Entomological Division of the United States Department of Agriculture, it is stated that in Colorado some of the migratory swarms have been successfully inoculated with this disease, and from Louisiana Professor Morgan reports a measure of success. In each of these cases short-horned grasshoppers are the subjects, and in each there were *great swarms, in which specimens were in, or came into*, easy contact with each other.

FIELD RECORD.

At the time of my first visit to the cranberry bogs, August 19th, the katydids were obviously immature sexually; that is, they were not then ready to reproduce. This was determined by examining the ovaries of the female, in which all the eggs were yet very small. The ovaries, which form masses on each side of the abdomen, as elsewhere described, could be readily seen when the body was laid open with a pair of sharp-pointed scissors. The immense bog area covered by the insects, and the wide range of plants which might serve for oviposition, made any effort to find the eggs under natural conditions a serious undertaking, without some clue as to the character of the vegetation favored. This was the more so as there was every reason to believe that the eggs would be laid in leaf tissue, following the habit of an allied species as recorded by Miss Murtfeldt, Dr. Riley and Mrs. Dimmock.

I decided, therefore, to cover certain portions of the bog where katydids were abundant, with large cages; confine in each a number of specimens and select locations, so as to obtain as large a range of plants as possible. Six cages were ordered, 3 x 3 x 3 feet, made so as to be readily taken apart and set up. The sides and top were covered with painted wire mosquito netting, to admit light and air with as little hindrance as possible. The appearance of one of the cages is shown at Plate, Figure 18.

Meanwhile, Miss White was good enough to send me specimens at short intervals, that I might watch the development of the ovaries. At the end of August some specimens began to show single mature eggs of a brown color, and the cages were shipped to New Lisbon.

September 6th, I followed and placed them as follows: No. 1 on a bushy hummock at one corner of a bearing bog. The ground was covered with vines, but several low plants of the Dwarf Cassandra, leather-leaf or "gander bush" (*Chamædaphne calyculata*), were included. Nos. 2 and 3 were placed close together on a young bog where katydids were abundant and berries badly eaten. One cage contained, besides vines, several plants of the common "bog grass" or sedge (*Carix sp.*), the other, several plants of *Panicum dichotomum* or "deer grass." No. 4 was placed at the end of the same bog, covering very few vines and a mixture of grasses, with a few plants of *Hypericum*. No. 5 was in a corner of a yet younger bog, covering very few vines and a mixture of *Panicum* and *Hypericum*, much like No. 4. No. 6 was placed on a dam, covered no vines at all, but a lot of double-seeded millet (*Panicum viscidum*), a Kalmia and two or three other heath-plants. None of the cages covered cranberry plants only, and in only two of them were there any berries on the covered vines. Into each of these cages at least four females and three or four males were introduced. The day was intensely hot, the mosquitoes (*Culex sollicitans*) were vicious and there was no inducement to waste time in the field. Next morning I visited all the cages, added other specimens and collected largely, to determine the stage of development. Found that it was not yet at the ovipositing point, though many examples had two or more fully-developed brown eggs. Examined a large number of leaves of all kinds growing on bogs or dams, but found no signs of eggs in any of them.

September 14, again visited the bogs, collecting and examining a large number of katydids. Found the ovaries much further developed, with often half a dozen or more mature ova on each side, but also many that were yet undeveloped. There was nothing to indicate that any eggs had been laid, and the abdomen in most of the females was much distended. The specimens in the cages were watched for a time and a few others were added. In cage No. 4 a specimen of *Argiope*, the large yellow and black spider, not uncommon on the bogs, had taken possession, its web dividing the cage lengthwise, and here all the specimens were gone. Cleared out the spider and restocked the cage, having first examined carefully all the vegetation under it, for eggs. The habits of the insects had changed a little by this time. They were not so uniformly spread over the bog, and were not eating berries so freely. On many tempting patches of ripe berries not a specimen was to be found; but among grasses and along the dams on the bushes any

Fig. 7.

Panicum dichotomum, or "deer grass," showing Katydid eggs at E somewhat less than natural size. *From an original photo.*

Fig. 8.

Tip of a spray of *Panicum dichotomum*, or "deer grass," showing the eggs at E and places where eggs have been eaten out, at A. From an original photo—twice natural size.

number was seen. In fact, the tendency to gather along the dams was very marked and almost every seed on the grasses there was eaten. All sorts of exposed seeds were now devoured and favored; probably because they were easier to get at than those of the cranberry. Examined a large number of leaves of Kalmia, and other heath-plants growing on and along the dams, but found no eggs.

September 23d was the date of my next visit, and cage No. 5 was first examined. The females had evidently begun to oviposit, because the ovaries were much lessened in size and the number of eggs was reduced as compared with previous examinations. So the plants under the cage were systematically scrutinized, leaf for leaf; first the *Hypericums*, then a small heath, and finally *Panicum*, or deer grass, almost as a last resort. Here I found the eggs inserted singly, from the edge, between the upper and lower surface. Plate Figures 7 and 8 illustrate their appearance clearly. Having once identified them, there was no further trouble, and I found eggs in every plant under the cage. I also found them, more sparingly, in the same grass on the bog. It was thus determined that the "deer grass" (*Panicum dichotomum*) was one of the natural places for oviposition, and not one forced upon the insect, because nothing else was available. The cage was placed in a new position, aud a number of females, which from their appearance had not completed their egg-laying, were placed in it. Cage 6 was then examined. A heavy rain had washed away the sand banked around it at the bottom and the specimens had disappeared. Examined first the grasses, and found eggs at once, in tbe leaves of the "millet" (*Panicum viscidum*). Afterward examined carefully all the leaves of the other plants in the cage and found no eggs in any of them. This cage was not restocked. Examined then a large number of the millet plants on the dams and found eggs in a very fair proportion of them. It was obvious that, while oviposition was in progress, it was a long way from complete. Left matters as they were in the other cages, satisfied with the information then obtained, and returned again to the bogs October 7th for a final search.

At this date the katydids had become much reduced in numbers, were more sluggish and more easily caught tban on any previous occasion. Quite a number of the females were found with the abdomen collapsed and ovaries practically emptied. Others, however, showed half a dozen or more fully-matured eggs and a greater number undeveloped. In other words, egg-laying was yet in progress, making a period of at least three weeks during which this pro-

cess continues. In fact, judging from my previous observations and from the condition of affairs at the last visit, I conclude that from September 15th to October 15th would probably be required to cover the entire period. Cage 1, when examined, showed eggs on every plant of "gander bush" or Dwarf Cassandra; but none on any cranberry leaf. The eggs were placed from the edge as usual, and from one to four in one leaf. They were never placed close together, and most often there were only two eggs, one on each side of the midrib. In one case a leaf hardly larger than a good-sized cranberry leaf contained an egg. There were many little bushes of this kind on the ridge on which the cage was placed, and I examined quite a number without finding any eggs, nor did I find eggs in similar plants later in the day, though I examined a large number. After the eggs had been once found it was easy to determine their presence by holding the plant toward the sun. The egg made an opaque spot that was recognizable at a glace ; hence all the leaves on a plant could be examined in a few moments. My conclusion is that, while the insects will use the heath-plants for egg-laying purposes when driven to it, they will not do so as a matter of choice when their normal host-plant is present. Cage 2 contained only sedge or bog-grass other than cranberry vines, and I found in almost every leaf of the sedge one or two eggs, separately placed. The immediate vicinity of this cage had much of this sedge growing, and I cut and examined many plants, finding no eggs outside the cage. I conclude, therefore, that this also is not a normal host-plant, and that only necessity will induce the katydids to oviposit in it ; but they can do so. Cage 3 had *Panicum* as well as sedge, and eggs were found on *Panicum* only. Cage 4 also had *Panicum* as well as *Hypericum* (St. Johnswort), and eggs were confined to the former. Many eggs were now found on the bogs and dams, but few on the bogs as compared with the dams. The insects leave the lower, damp places and select by preference, for egg-laying, the higher, dry areas. On the "deer grass" the upper leaves are selected, and I rarely found more than one egg to a leaf outside of the cages. On the millet the lower leaves were favored, and on one I found as many as six eggs, probably laid by one female at one sitting. Two, three and even four eggs were not uncommon, and my conclusion is that this grass (*Panicum viscidum*) is the preferred host-plant of the cranberry-eating katydid. It grows on all the dams, and especially along the cart-ruts. On bogs, it is on recently-stirred land only. Mr. White informs me that the grass tends to run out after a few years, as the ground firms down—and they do not consider it a menace on their young bogs.

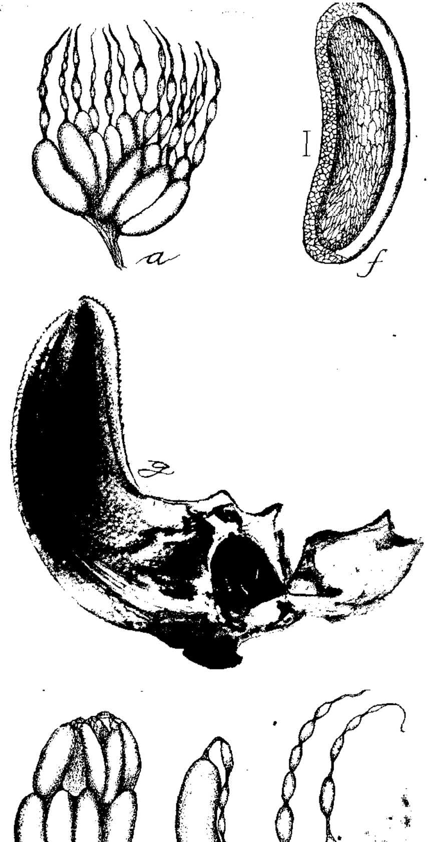


Fig. 9.

Ovary, egg and ovip sitor of Cranberry Katydid. *a*, ovaries in September; *b*, a single ovarian tube of same date; *c*, single ovarian tube further developed; *d*, shows the infolding of the upper portion of ovarian tube; *e*, ovaries in early October, showing eggs almost mature in a double series; *f*, single egg; *g*, the ovipositor from the side. All are enlarged and all original—*g* from a micro-photo.

For second choice, there is *Panicum dichotomum*, or deer grass, and this grows more commonly on the bogs and sides of dams. On the bogs it also runs out in time, but maintains itself along the edges and on the dams. It is, perhaps, the more common host for the katydids infesting older bogs. It is probable that any other species of *Panicum* would be acceptable to the insects, and, as I have shown, they will, when driven, take almost anything other than cranberry. I doubt whether they would take cranberry if anything else was available, but I would not like to say they could not do so.

Whether the eggs laid on bogs covered with water during the winter can survive, is a question. It seems probable that they cannot, for immature katydids are rarely seen there. The eggs of the *Xiphidium*—the smaller long-horned species—certainly do survive, but they are much better protected than those of the katydid.

Life History.

Briefly stated, the life cycle of *Scudderia texensis*—the cranberry katydid—is as follows: Eggs hatch about the middle of June; the young grow slowly, and reach the pupal stage about July 15th. Winged adults appear early in August, and remain until well along in October. Oviposition begins about the middle of September, and proceeds slowly for almost or quite a month. Few eggs mature at one time in the ovaries of the female, and she lays from one to six at a sitting—the latter an extreme rarely reached. The preferred host-plants are species of *Panicum*, but others may be used in case of necessity.

Eggs and How Laid.

I have referred in my general account to the ovaries and to the development of the eggs in them. Early in the life of the adult female these organs are rather small masses or bundles lying far back in the abdomen, one on each side, partly under the digestive system. The masses, when hardened in alcohol and teased out a little with needles, resolve themselves into a number of tubes, converging at the bottom and top, and each with a number of enlargements or swellings. These are ovarian tubes, and in them are the developing ova. The tubes number from 13 to 15 on each side, and in each are five swellings or forming eggs. Potentially, therefore, an individual katydid may produce 75 eggs in each ovary or 150 all told; as a matter of fact she never does this. Copulation has been observed to occur during the

early days of August and probably occurs throughout that month or even later. Males in good condition were found as late as the middle of September. After the female is impregnated the eggs develop slowly, and only the lowest egg in each tube increases in size. About the first days of September we get the appearance shown in Figure 9*a*. Here all the eggs of the lower series are developing and the others remain, very little, or not at all enlarged. Not all the lower eggs are equally enlarged and one or two become brown on each side and full-sized before the others begin to change color or have attained normal dimensions. The ovaries are now of considerable size and fill a large part of the abdominal cavity. The tubes above the lower eggs are bent over so that they lie in the spaces formed between the enlarging ova. A single ovarian tube is shown at Figure 9*b*, representing the stage of development shown in the preceding figure. As the lower egg increases in size, the space between it and the next ovum lengthens, as shown in Figure 9*c*, and then the single tube is bent over, as shown in Figure 9*d*. If, therefore, we examine an ovary about the middle of September, we will see a mass of large eggs, and, packed in between them, the tubes containing those that are undeveloped. Some of the eggs are now fully mature, and the others are so fast approaching full size that it is no longer possible for them to lie together in a series. The smaller and less developed examples slip up, as the lower part of the ovarian tube lengthens, and we get the appearance of a double series, as shown in Figure 9*e*. By this time egg-laying begins, and toward the end of September the number of large eggs lessens materially, while in October the females have the abdomen collapsed, and with few or no developed eggs. Examined at this time, the ovarian tubes are shrunken and show no indications that any of the ova yet rudimentary in the ovarian tubes has any chance of development. The specimens are now listless, fly feebly, or not at all, and have a generally collapsed feeling that indicates the end of their existence. They have also become much reduced in number, and evidently their season is nearly over. In other words, though each ovarian tube indicates five egg cells, yet, as a matter of fact, only one develops, so, instead of the possible 150 eggs, each female individual actually lays only 30, or less. How long a time she requires to complete her task I do not know, but that all are not laid at one time is clearly proved by the fact that among the specimens captured and examined on the bogs September 23d, most of them had several ova on each side in varying stages of development, while it was obvious that some eggs had been already laid, because

the total number remaining was less than would have been the case otherwise.

All the growers to whom I have shown the eggs in position in the leaves have expressed surprise at the possibility of the insects accomplishing so delicate an operation as cutting a pocket in so thin a leaf and placing an egg between the upper and under surfaces without rupturing either. The operation has not been observed in this species; but so long ago as 1874 Dr. C. V. Riley published in his Sixth Missouri Report the following account of observations made by Miss M. E. Murtfeldt: "The female stations herself firmly, by the middle and hind legs, on twigs or leaves contiguous to the one selected to receive the egg. This leaf is then grasped by the front feet and held in a vertical position, while the edge is slightly gnawed or pared off by the jaws, to facilitate the entrance of the point of the ovipositor. When this is done the abdomen is curved under and brought forward, and the ovipositor is seized on its convex edge by the mandibles and maxillæ, which, with the aid of the palpi, guide the point to that portion of the leaf prepared to receive it. After gentle but repeated efforts, the point of the instrument is finally inserted between the tissues of the leaf and gradually pushed in to more than half its length. As soon as the cavity is formed, the egg is extruded and passed slowly between the semi-transparent blades of the ovipositor. As the egg leaves the ovipositor the latter is gradually withdrawn, while the egg remains in the leaf, retained in its place, probably, by a viscid fluid that is exuded with it. The insect occasionally deposits two or three eggs in succession, but, as a rule, after one is placed she releases the leaf and betakes herself to eating, or to biting her feet, or dressing her antennæ, and does not resume her maternal duties for some time."

It is more than probable that this is very nearly what occurs with our cranberry species, and that only a few eggs are placed at one point. Dr. Riley mentions five for his species, but Mrs. Dimmock describes a birch-leaf about three inches in length, in which she counted 102 eggs around its edge. It would be interesting to know how many specimens co-operated in this performance.

The ovipositor with which this work is done is a curved scimetar-like organ about one-quarter of an inch in length, and by no means a simple structure, since it is made up of six distinct pieces. Pl. 9*g* figure shows a side view made from a photograph. Two of the pieces of one side are very clearly shown, and the fact that the edges are furnished with fine saw-teeth is apparent. The other, or

third piece of this same side, lies inside of the two shown in the picture at about the line of the division shown. This inside piece is narrower than the others, of even width throughout, with an obliquely-pointed tip. It has no teeth, is not used in the mechanical work of cutting the leaf, and serves chiefly, if not entirely, as a guide to the egg as it passes between the two sides of the ovipositor. Miss Murtfeldt suggested that the egg is held in position in the leaf by a sticky substance when the ovipositor is withdrawn, and this is no doubt correct. I have tried to separate out the egg from its pocket on several specimens, and have always failed to do so without either breaking the shell or leaving parts of the leaf tissue adhering to it. If the edges of the pocket are closely trimmed around the egg with a pair of scissors, so as to separate completely the upper and under surface of the leaf, the two parts nevertheless adhere so closely to the surface of the egg that they cannot be parted.

When deposited in the leaf-tissue the egg is almost three-sixteenths of an inch in length, less than half as wide, very flat and slightly kidney-shaped—that is, the ends are rounded, the outer edge is somewhat convex and the inner correspondingly concave. In color it is light leather-brown or somewhat dirty clay-yellow. Under the microscope their is a narrow, smoother edging, the surface of which is regularly marked with hexagonal reticulations at the ends and on the concave, inner side. The central surface is closely and roughly marked or netted without definite pattern.

Remedial Measures.

The observations made have been given in some detail, to lead up to an intelligent consideration of this subject. We can place no reliance on disease; the food-habits are such as to preclude the use of insecticides; turkeys, though quite effective on a limited scale, are considered objectionable and unsatisfactory, for a variety of reasons, by the owners of extensive areas.

Several growers have told me that after burning over the ground surrounding the bogs they have noticed a marked decrease in the number of katydids the season following. In fact, I have advised this practice because of my conviction, based upon the knowledge of the habits of allied species, that the eggs were deposited somewhere near the bogs in leaf-tissue.

Having determined the actual host-plants, the obvious measure is to burn over during the winter all grassy areas surrounding the bogs

Fig. 10.

The Cyclone burner at work. (From Forbush and Fernald, "The Gypsy Moth," Mass. Bd. of Agl. 1896.)

or on the dams. This can be done at any time after winter has set in, and is best done when the ground is frozen, that the fire may not get into the turf. Do not take any action until the egg-laying season is entirely over and the water is on the bogs.

Bogs that are very grassy should, if the grass is a species of *Panicum*, be cleared as well as possible, or, if that be not feasible, the grass should be mowed after the middle of October. The grass is quite tall, and the eggs are laid in the upper leaves of the *P. dichotomum*, or deer grass. Hence, it can be cut above the vines with a scythe, or, on new bogs, a mowing machine may be used if the horses are provided with lawn shoes. There is no necessity for raking up or burning it. It will decay in the water long before the season following.

For burning over dams or underbrush without starting a large fire, a machine like that used by the Gypsy Moth Committee, in Massachusetts, and termed by them a "cyclone burner," would be very useful.

This is, essentialy, a twelve-foot gas-pipe, at the end of which a cyclone of Vermorel nozzle with a very fine opening is fitted. Half of this rod is encased in wood, that it may be safely handled, and the pipe is connected by a short hose with a small pump fitted in a large bucket. Figure 11, which is from the Gypsy Moth report for 1896, will explain more fully. The pump is operated by one man, while another directs the nozzle. The oil emerges as a fine, mist-like spray, which is easily lighted and burns with a very intense heat, destroying everything in its path in a moment, without necessarily setting much, if any, fire. Every leaf could be burnt off any shrub without more than singeing the wood, and the grass could be burnt off the surface without even thawing it. Paraffine-gas oil was used in Massachusetts, but simple crude petroleum will do if the odor is not objectionable. A special oil hose is

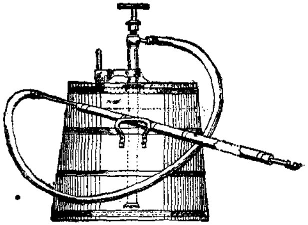


Fig. 11.
The cyclone burner: shows the general construction. (From Forbush and Fernald, Mass. Bd. Agl., 1896.)

advisable if much work is to be done, because the oil attacks ordinary rubber. So no solder can be used in the nozzle fittings, because of the intense heat of the flame. It seems scarcely necessary to go into more detail on this point, as, with the problem clearly stated, our cranberry growers are perfectly competent to work out the details of the application.

The Species.

Since my previous writings on the cranberry Orthoptera, Dr. Samuel H. Scudder, of Cambridge, has published a revision of the species belonging to this group, and the name applicable to our species is found to be *Scudderia texensis* Sauss. It is the same form that I called *Scudderia furculata* in my Bulletin No. 90, the latter name being no longer used for any of our forms. All the specimens found on the White bogs this year were of this species. I did find two examples of the larger form, called *Microcentrum*, but these were so rare that they could hardly be counted as worthy of attention. From my collections of previous years it is probable that one other form (*Scudderia furcata* Brun.) also feeds on cranberries, and this is a species that probably lays its eggs in the leaves of oak, birch and other trees. It is likely that, where such trees come close to the edge of a bog, the insects will get on it and eat berries. Hence it is advisable to brush out the undergrowth for some distance back from the edge, to deprive them of their natural retreats and remove temptation from those that may appear further off.

MOSQUITOES.

New Jersey has always had a reputation for having more numerous and fiercer mosquitoes than any other of the United States. The newspaper writer and the caricaturist have both found something to say concerning this one of our prodûcts; so that the Jersey mosquito is scarcely less celebrated than the Jersey lightning. We have had these insects pictured as carrying off cattle; as lying in wait for the new arrival at the summer boarding-house; as sharpening up their bills on the grindstone, preparing for the season's work, etc. Of course, there is some basis for this ill-report—not that New Jersey is really worse than some other localities in the United States. Staten Island and Long Island will rival the New Jersey coast in the number and bloodthirstiness of its product; and who that has ever been in the North woods does not remember the swarms that greeted

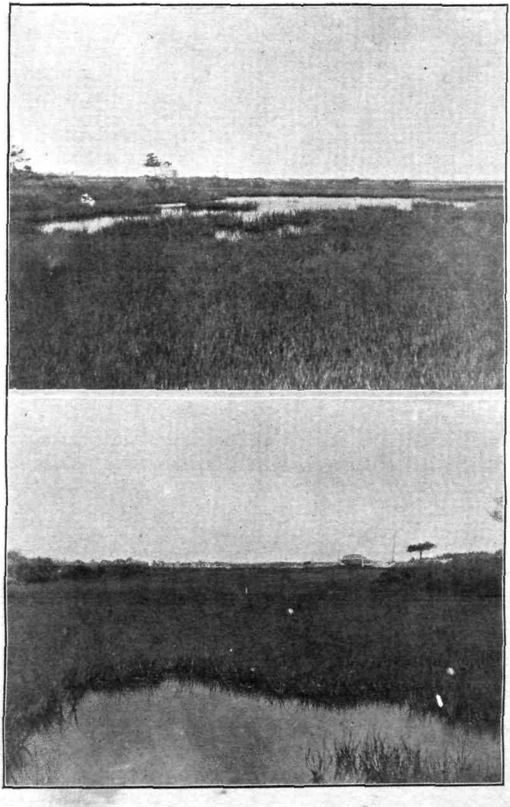


Fig. 12.

Typical areas where *Culex sollicitans* breeds. Small pools are in the meadow everywhere, and the whole is a great sponge in which the boot sinks from 4 to 6 inches. From original photos.

him and the tar mixtures that were required to preserve even a semblance of comfort, while hunting, fishing or sitting outdoors at night! It is not a matter of climate, because they are worse in parts of Louisiana than they are in parts of New Jersey; and very much worse in Alaska, at the very fringe of the Arctic regions. It is simply a matter of opportunity for breeding, and in that respect New Jersey offers peculiar advantages. Not all parts of our State are equally infested; there are some sections where the mosquito is a rare bird; where the season may be passed without a single specimen being noticed, and where, from the practical standpoint, they require no attention whatever. But we have a long coast line, extending from Jersey City to Cape May; indeed, practically, the line extends along the valleys of the Hackensack and Passaic rivers for a considerable distance north, around Cape May, along the shores of the Delaware bay, and for a considerable distance up the Delaware river. Along the Atlantic coast the tendency is to a formation of a series of bars. This begins at Sandy Hook, breaks at the Highlands and, beginning again at Bay Head, continues to Cape May Point. These bars vary in width, and vary also in their distance from the mainland. Sometimes they are only a few hundred feet wide; at other times, a mile or more. Occasionally the region between this outer sand-bar and the shore of the mainland is almost filled with marsby meadows, usually with an inlet or creek running through them, to a neck of land that connects the bar with the mainland. At Barnegat bay the distance increases until it is four or even five miles in width, and at Great bay there is a considerable body of water. On the bay side of these sand-bars, and on the shore of the mainland, we have immense stretches of salt marshes, and these run a considerable distance up the streams that empty into the bays. The whole vast area so generally described forms one immense breeding place for certain species of mosquitoes. A visitor to the seashore, in crossing these marshes, finds that the train becomes filled with mosquitoes, even before he reaches his destination, and, if he arrives when a land breeze is blowing, life is almost unbearable. There is a decided difference in the number of these pests at different points along the coast. In some places mosquitoes are present only under certain conditions; at others they are always abundant—always a nuisance! Were it not for the presence of these insects there would be no more delightful summer resort than the whole stretch of New Jersey coast, from Bay Head to Cape May. It offers everything that is attractive to the fisherman or any-

one enjoying aquatic sports, while to him that seeks health, the sea breezes furnish an inexhaustible supply of the best kind of tonic. Yet many people will not go to this shore solely because of the mosquito pest. Those who would otherwise do so will not build cottages or more pretentious homes because of the difficulty of keeping out the insects and because of the necessity of barring everything with netting, if even a fair amount of comfort is to be obtained, when the wind comes from certain directions. I have traveled along this whole coast, not only during the past summer, but in previous years, and I feel that I am safe in saying that the value of shore property would be many times multiplied were it not for these insects, and that the number of people going to the shore would be many times increased did not the dread of the mosquito pest keep off the would-be visitors. It has been no unusual experience for boarders to abandon a seacoast hotel in a body simply because of the mosquitoes, and many a party has cut short its stay on that account. Many millions of dollars are lost in the value of the property and many thousands are annually lost in earnings.

The importance of the problem has been only recently brought to public attention. The insect has been with us for so long a time that, somehow, it has come to be the feeling that there was nothing to do but to bear with it. Mitigate the nuisance wherever it was possible, of course, but as to doing away with it in even large part, that seems to have been considered as not worthy of consideration. But it has been shown that the mosquito is not only a nuisance—it is a positive source of danger to health, and in the transfer of certain febrile diseases it is a necessary intermediary. Public attention, directed to the insect for this cause, was ready to heed the suggestion that possibly much could be done to lessen the numbers of the pest. Dr. L. O. Howard, Entomologist to the United States Department of Agriculture, has observed the mosquitoes for a number of years past, and during the early part of 1900 published a book in which he gave a comprehensive review of what had been done, what might possibly be done, and included suggestions for general practice.

It was not possible for me to be long in New Jersey without being, to some extent, attracted by mosquitoes. I have, therefore, made observations, in a more or less fragmentary way, for some years past, and had made a considerable collection of specimens without directing my studies toward the practical point of dealing with the insects. After the publication of Dr. Howard's book, and in view of some rather interesting observations that had been made on two or three

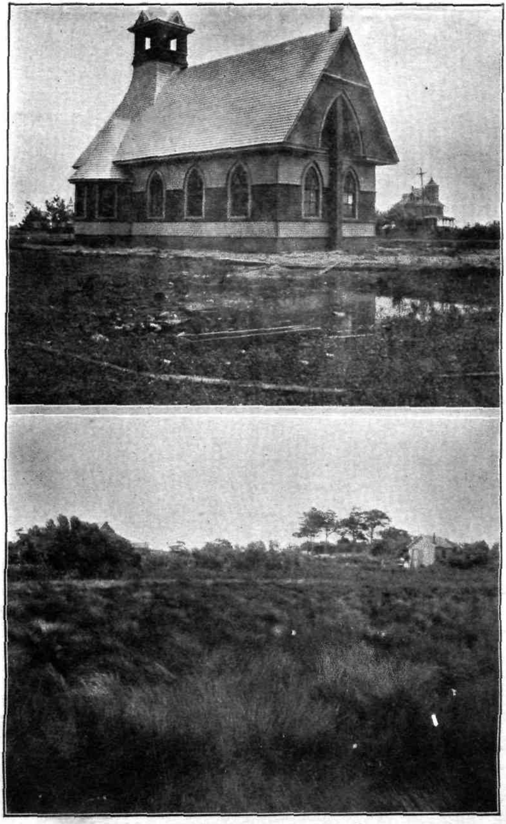


Fig. 13.

Mosquito-breeding places. Above, a church with stagnant pond area next door, furnishing a bountiful supply of mosquitoes throughout the season; below, a salt meadow with about three inches of water, swarming with larvæ of *sollicitans*. From original photos.

South Jersey species, it was decided to take up the problem in a systematic way, with the view of determining the possibility of influencing the number of specimens and recommending practical measures for their control. Systematic collections and observations have been made at many points in the State, and in this I have been materially aided by a number of voluntary assistants, whose services will be elsewhere acknowledged.

The mosquito, as a carrier of malarial troubles, is decidedly a factor in State sanitation, hence I determined to enlist the co-operation of the local authorities thoughout the State, and, during the early part of July, prepared a circular letter, which was sent to the secretary or inspector of every board of health, for which an organization was reported in the twenty-fourth annual report of the State Board. There are reported 36 cities, 83 boroughs, 136 towns, 3 villages and 200 townships—in all, 458 organized boards. To all these and to a few other officers, where apparently there were no organized bodies, a copy of the following circular was sent:

NEW JERSEY AGRICULTURAL COLLEGE
EXPERIMENT STATION,
NEW BRUNSWICK, N. J., July 15th, 1901.

ENTOMOLOGICAL DEPARTMENT—EDWARD B. VOORHEES, DIRECTOR; PROF. JOHN B. SMITH, ENTOMOLOGIST.

DEAR SIR—It is my intention to devote some time during the present season to an investigation of the mosquito question as it exists at the present time in New Jersey. The recently-established connection between malaria and mosquitoes makes this matter important from the sanitary standpoint and gives it a direct bearing upon the health of the community. For this reason I have asked the co-operation of the State Board of Health and have received from its Secretary, Dr. Henry Mitchell, cordial assurances of support.

It is necessary, however, to make my work complete, that I should also enlist the co-operation of local boards throughout the State; therefore, I beg you for information on the following points:

First. Is "malaria" a prevalent disease within your jurisdiction—*i. e.*, are the cases at all numerous?

Second. If cases are numerous, are they localized or are they scattered throughout the community?

Third. Is one case apt to be followed by others close by?

Fourth. Are mosquitoes numerous in your jurisdiction, and if so, are they generally spread, or is one part of the district more infested than others?

Fifth. Have you observed any relation between the abundance of mosquitoes and the prevalence of malaria?

Sixth. If mosquitoes are plentiful can you tell where they breed?

Seventh. Will you send me from time to time specimens of the troublesome mosquitoes in your jurisdiction? I will supply as many vials as are needed and will be

glad to give whatever information is desired as to the methods of collecting and preserving.

Eighth. Any further information bearing on the above matters is desired and will be appreciated.

It may be added that the information obtained will not be published in such a way so as to prejudice any particular locality, but is necessary to establish facts and relations. It is also to be used as a basis for recommending measures to mitigate or locally abolish the mosquito pest.

Awaiting your early and—I hope—full reply, I am,

Very truly yours,
JOHN B. SMITH,
Entomologist to the Experiment Station and State Entomologist.

The replies were not as numerous as I could have wished, but they were fairly well distributed, and the information obtained was interesting. A summary, so far as present applicable, is given on a following page. It soon became evident that the question of control was at once a simple and a complicated problem; it was simple, because the methods of dealing with the pest appear to be tolerably obvious; it was complicated, because it also became evident that the occurrence of insects in swarms, at one particular point, was no evidence whatever that they bred anywhere within several miles of the place where they were so abundant. Some localities seem to be dependent upon a local supply, and, curiously enough, some species were found to be very local in their distribution. It was realized, therefore, that while it was quite possible to control the pest to a considerable extent, even to a point of lessening them by at least 75 per cent., this cannot be done if it is left to individuals or local authorities alone. It is quite possible for the village, town or township, in some parts of the State, to practically wipe out the pest, by systematic work, in its own locality. But there are other places where local work would be thrown away, because the mosquito supply comes from a distance, and where the local output hardly forms a factor important enough to attract attention. Therefore, it was decided that before any valuable recommendation could be made it would be necessary to study carefully the distribution of the various species, to ascertain the breeding places of those that were most widespread, and to determine the condition under which migrations, if any such there were, would take place. It was necessary to determine just how far local work would be useful, and how far it would be necessary for the State to assist, where the control of the insect is not strictly a local problem. This investigation has been made, as far as it was possible to do it, during the past summer, but it is by no

means completed. In fact, only enough has been accomplished to indicate what should be done in the future. It will be readily realized that, without any special fund for securing assistance and without any reduction of the regular work of the Station, it was an impossibility to cover the subject as fully as it deserves. After some consideration, I devoted myself chiefly to the study of the habits, breeding places and migrations of the shore mosquito, and the distribution and breeding habits of the malaria carriers. If we consider the shore or salt marsh form in a limited area, it will seem at first as if no great difficulties were in the way of its control. Some seaside communities have actually done considerable work, with good effect in lessening the number of the pests; but when one stands at the edge of a marsh like that bordering the Great bay, finds the insects rise in clouds on all sides of him, and sees the millions of opportunities extending for miles around, the dominant feeling is one of discouragement. I have traveled this year from Cape May north to Atlantic City, along the coast of Barnegat bay, across the inlet to the main land at Bay Head. I have found at all these points mosquitoes in all stages and in great numbers. I have had my assistant, Mr. Dickerson, investigating the marshes in the vicinity of Elizabeth Port and the meadows east of Newark. He has learned some of the conditions under which the insects breed there, and the general results of what we have observed are given in this report. It will need a body of trained men to go over this whole territory systematically, to complete the observation begun this year. It will need a closer study than has already been made of the peculiarities of the different species, in selecting places in which to breed. It is by no means true that all mosquitoes will breed whenever they find a supply of water, though without water there can be no breeding. Some of them are rather particular as to the localities in which they will lay their eggs; others seem to find no place so foul or so unlikely that they will not take an opportunity to oviposit. When we know the habits of all these species, just how far they will spread, and the circumstances which further their development, we will be in a position to take effective measure for their control. I can see no reason why, with a sufficient force, this work could not be done within the space of one full year, and why it should not be possible to present, by the spring of 1903, a general plan for the control of the mosquito pest, *which could be begun at any time, in any locality, and systematically* carried out, until it is reduced to so small a factor as to make it harmless and inoffensive.

To make this investigation as thoroughly as it should be done will require the expenditure of $10,000, that it may be promptly completed and the report available for use in 1903.

MOSQUITOES AND MALARIA.

That there is a direct relation between mosquitoes and the disease called malaria is generally accepted by investigators at the present time, but whether or not other factors are necessary for the epidemic occurrence of the disease is by no means as well settled, nor is the agreement so general.

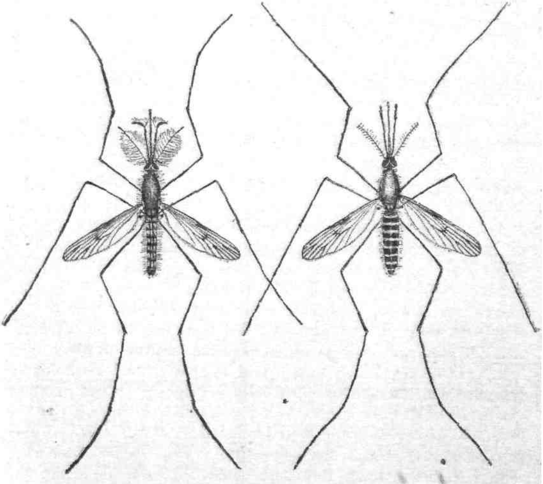


Fig. 14.
Anopheles maculipennis: male at left, female at right—enlarged. (From Howard, Bull 25, n s., U. S. Dept. Agl., Div. Ent.)

It may be fair to say that it seems proved that without mosquitoes of the genus *Anopheles* there can be no transfer of malaria from one individual to another except by a direct transmission of blood from

the diseased individual to one tbat is healthy, but we cannot say definitely that it does not also require some specific surroundings or other condition to make the transferred organism active.

As is usual in matters of this kind, there are rival claimants for the honor of discovering the relation of the insect to the disease; but it is no part of my purpose to follow out what each of the many indviduals who has studied this problem has contrbuted to its solution. The present state of our knowledge concerning the malarial parasite is so clearly and succinctly stated by Dr. L. O. Howard in his book on mosquitoes that I quote in full:

"All of the malarial parasites are protozoans; that is to say, animals—and not hacteria; that is to say, plants. In the human blood these protozoa inhabit the red blood corpuscles, and in the blood they go through a sporulating existence, which may continue indefinitely unless checked by quinine or some other way. In the red corpuscle the parasite appears as an amœbula, which gradually grows until it nearly fills the interior of the corpuscle, digesting, apparently, the coloring matter of the blood and forming, as the result of this digestion, pigment spots in its interior. On reaching full growth the nucleus of the amœbula subdivides, each division gathering about itself a certain amount of protoplasm, until, instead of the single amœbula, the corpuscle contains a large number of spores. The walls of the corpuscle then break and the spores are liberated into the blood sernm. From a single infection, this sporulation or liberation of the spores takes place practically simultaneously and marks the hegining of the malarial spasm.

"The three different kinds of malaria, namely, that in which the fever recurs every two days, known as tertian malaria; that in which the fever recurs every three days, known as quartian malaria, and the severe autumn fever, known as æstivo-autumnal fever, or tropical malaria—by far the most dangerous of the three—are by some writers supposed to be caused by distinct species of parasites. This view is not held by other writers. But, at all events, the period of development of the sporulating stage of the organism differs in length of time. As is very well known, it frequently happens that the malarial fever or chill will recur every day. That means, in tertian malaria, that there has been a reinfection on one of the alternate days, the development of the amœbulas being constant in point of time, one set sporulating twenty-four hours after the other set. It is just as this sporulation occurs, just as the spores are liberated into the blood serum, just as the malarial spasm is about to begin,

that the administration of quinine is most affective. It seems to kill the spores when they are liberated, but appears to have very slight effect upon the organism when it is enclosed in the red blood corpuscles.

"This sporulating development, each of the liberated spores attacking and entering new red corpuscles, may continue, as above stated, indefinitely. But not all of the amœbulas undergo this development. Some of them, so long as they remain in the human body, apparently die and are digested by the leucocytes.

"When, however, these forms are taken from the human body, even when a blood sample is simply placed under the microscope for examination, they undergo a development entirely different from the sporulating form. Some of them grow large, others put out slender filamentary arms, or flagella, as they are called, which separate from the body of the organism and fuse with those which do not flagellate. This is the true sexual generation of the parasite, the flagellating forms representing the male sex and the receptive forms the female sex. The development up to this point will take place anywhere outside of the human body, in the stomach of mosquitoes of the genus *Culex*, or, presumably, of other biting insects, but it is only in the stomachs of the genus *Anopheles*, so far as observed, that a further development takes place. After the fusing of the flagella with the female germs in the stomach of the Anopheles mosquitos, the fertilized organisms attach themselves to the walls of the stomach, penetrate the inner walls and locate themselves just under the outer muscular wall. They then rapidly increase in size until they eventually become five times as large as first. They are now known as zygotes. Clear spaces begin to appear on the surface. These clear spaces are known as centromeres, and they are rapidly surrounded by minute, short, dark lines, which, when seen under a very high power of the microscope, are shown to be spindle-shaped cells, known as blasts. These blasts rapidly increase in number until eventually they fill the entire zygote, obscuring the centromeres, and when this condition of affairs is reached the zygote bursts and the blasts are liberated through the muscular wall of the stomach into the body cavity of the mosquito. They are active and penetrate rapidly into the tissue of the salivary duct, and so into the proboscis of the mosquito, and, with the saliva or poison, they enter the blood of the next warm-blooded animal which the mosquito bites. It is then supposed that the blasts enter the red corpuscles and the development re-begins at the stage where we took it up.

"It is thus shown that the full devolpment of the malarial parasite cannot take place within the human body; that the Anopheles mosquitoes are necessary secondary hosts; that the sexual generation of the parasite takes place only in mosquitoes of the genus Anopheles, and further, that the old ideas of malaria from bad air (and of course the word *malaria* means bad air), swamp "miasma," and so on, are to the minds of those familiar with the subject of the biology of these low forms of life completly overturned."

Health Board Reports.

In reply to the circular letter previously referred to, reports were received from 20 of the 21 counties, Salem alone making [illegible] reports. In all, 98 formal reports were received; but some of these covered more than one jurisdiction, so that over 100 health districts were officially represented. My own collections, the collections made by Mr. Dickerson, and the material received from other correspondents, add materially to this number, so that it is fair to say that I have realiable information concerning the occurrence of mosquitoes and the prevalence of malaria from nearly 150 different points in the State. No present purpose would be served by presenting these reports in detail, interesting as they are; but a brief summary and analysis will prove instructive.

Of the 98 official reports, 14 was the greatest number received from any one county, and 2 was the smallest, 3 counties having this number to their credit. Seven counties present 18 reports that malaria is prevalent and cases are numerous. In a very few instances the large number of cases is emphasized. In one the reporting physician states: "I may say that during the summer and fall at least 70 per cent. of the people are affected. The particular type of malaria is the chronic form, thus showing that the disease remains in the system; * * * but these people are so thoroughly acquainted with the disease that they treat themselves. Yet their faces show the malarial cachexia." As the district represented by this officer is a populous one, his report represents many hundred cases.

One county reports no malaria at all; but from this I have only 2 reports. The county is scantily populated, health conditions are unusually good and, from my own observations, I believe that the disease is really rare, if there is not an entire absence of cases originating within its limits. That persons suffering from malaria go

into the county for a longer or shorter period I know, because it contains several popular shore points.

In all, 28 jurisdictions report "no malaria" and 15 counties are represented in these reports. In 5 counties all reports show the occurrence of more or less malaria, and 6 is the greatest number of places in any one county where where it was said to be prevalent. In the county sending 14 reports all show the occurrence of the disease to a greater or less extent.

In general, it may be said that the malarial part of New Jersey lies in the valleys of the Hackensack and Passaic and for a stretch along the Delaware river. Salt marsh districts are not especially unhealthy, but fresh water marshes are. The worst districts are where the fresh and salt water swamps merge, and where the fresh water marshes join the upland. Southern New Jersey seems, on the whole, quite free from malaria, and this exemption is shared by the majority of the highland regions along the Delaware, from Trenton to the northern boundary of the State.

The reports show absolutely no correspondence between the abundance of mosquitoes and the occurence of malaria; and this is not unexpected or unnatural. *Culex* may and does occur in swarms, where malaria is an unknown disease, and, as *Culex*, from its habits, is more likely to be observed than *Anopheles*, the reports concerning the relative prevalence of insect and disease are not conclusive. Yet a number of reporters seem to find a connection between the two, though a greater number declares to the contrary. The truth is that most of the reporters are, justifiably enough, ignorant of the distinctions between malaria carriers and mere nuisances, so that no positive conclusions can be safely based upon what is said by them. It does seem as if "no mosquitoes, no malaria" was generally combined, and malaria without mosquitoes is never reported.

As to the question whether one case of the disease is apt to be followed by others close by, there is the widest divergence. In most instances, cases were reported as "scattered," without apparent connection between them; but there are also statements concerning successive cases in the same family or district, that point very decidedly to some connection between them. As the matter stands now, no justifiable conclusions are possible one way or the other.

More than half of these sending reports expressed themselves as willing to send in specimens if I would furnish bottles and instructions, and to all these I sent from 3 to 6 vials partly filled with alcohol. Over 40 sent me one or more vials of specimens from as

many different localities, and a little over 100 vials were received back out of 250 sent out. The results were interesting as matters of distribution of species, but they cannot be presented here in detail. It is enough to say that *Anopheles* was rare as compared with *Culex*, and from the worst malarial districts no *Anopheles* at all were received. On the other hand, the largest numbers of this type came from districts where malaria was practically non-existent.

To supplement the material received from the health boards, Mr. Dickerson collected at a number of points in Essex, Union and Morris counties; Mr. Wm. P. Seal collected near Delair, in Camden county; Mr. C. W. Johnson collected near Riverton, Burlington county, and Mr. J. Turner Brakeley explored with great thoroughness the vicinity of Bordentown, Burlington county, and of Lahaway, in Ocean county. The remarkable collections made by Mr. Brakeley will be again referred to. My own collections were made from almost all counties south of Essex.

It may be as well to state in this connection my own conclusions on the subject of the relationship between *Anopheles* mosquitoes and malaria, based upon the observations of the past season.

I accept without question the published life cycle of the Plasmodium, causing malarial symptoms and effects and the necessity for the *Anopheles* as an intermediate host. I am quite convinced that without the mosquito there can be no transfer of the malarial organism from one individual to another; but I am not convinced that the two factors—a malarial subject and an *Anopheles*—are *all* that is necessary to cause an epidemic spread of the disease. Two towns of Middlesex county are less than five miles apart, and *Anopheles* is equally common in both. In one town malaria is prevalent and epidemic; in the other original cases are almost unknown. Yet each year cases from the one town go to the other for treatment. In fact, the case is stronger, for some patients work in the malarial town and live in the other. There is never a center of infection caused by such persons. Furthermore, there is plenty of communication between the two by rail and trolley roads, offering every facility for a spread of the disease. These are facts within my own knowledge.

Another case is a town in the pines with a hotel much frequented by invalids, and where malarial patients from Camden and Philadelphia come every summer. Almost all the mosquitoes collected for me at this hotel on several occasiones were *Anopheles punctipennis*. Yet no case of malaria has ever originated here or in the vicinity. On the contrary, the patients that lodge there get well. I might

multiply instances, were it necesary, even to the extent of showing that malarial districts in a town contained fewer *Anopheles* than others in the same town where no cases occurred. To the objection that the *Anopheles* that bred in the malarial district did not leave it, I can bring evidence tending to show the occurrence of specimens in exempt districts, that could bave bred only in the infected districts.

My conclusion is that there is a third factor necessary to produce malaria, concerning which we are yet in the dark, and as to which I do not care to make suggestions just now. I agree that *Anopheles* and a patient whose blood contains the specific Plasmodium are necessary; but they are not enough—the disease will not spread unless some other conditions are favorable.

How Mosquitoes Bite.

Common as mosquito bites are, few persons have watched the operation of biting. Seen with a hand lens of moderate power, the mouth parts of the mosquito seem to consist of a long and comparatively stout proboscis or trunk, at the base of which is a pair of short palpi or mouth feelers if we have a *Culex*, or a pair of processes as long as the beak itself if we have *Anopheles*. *Culex* seems rather particular as to the place selected for biting, and will hover about for some time seeking a suitable spot—hence the aggravating singing, which sometimes lasts a minute or two when at night you are waiting for the creature to alight and give you a chance at him. *Anopheles* wastes no time, and alights without preliminary investigation. Nor do all species of *Culex* act with equal deliberation, for *sollicitans* will bite much more promptly tban *pungens*. In any case, as soou as the insect alights the proboscis is applied to the flesh, and almost immediately a burning or piercing pain is felt. If the insect is left undisturbed, it will be seen that the proboscis itself is not inserted into the wound, but that it bends slightly near the middle and that it supports at the base and tip a much more slender, yellowish, hair-like structure, which is inserted deeply into the tissue. In an incredibly short time the abdomen of the insect will be seen to swell and to show the tint of the blood absorbed until it is so distended that it seems almost impossible for the creature to fly with its load.

If now the mosquito is smashed, it will be noted that the blood is unusually thin or liquid and spreads over a larger surface than an equally large drop taken from a prick or cut directly out of the body.

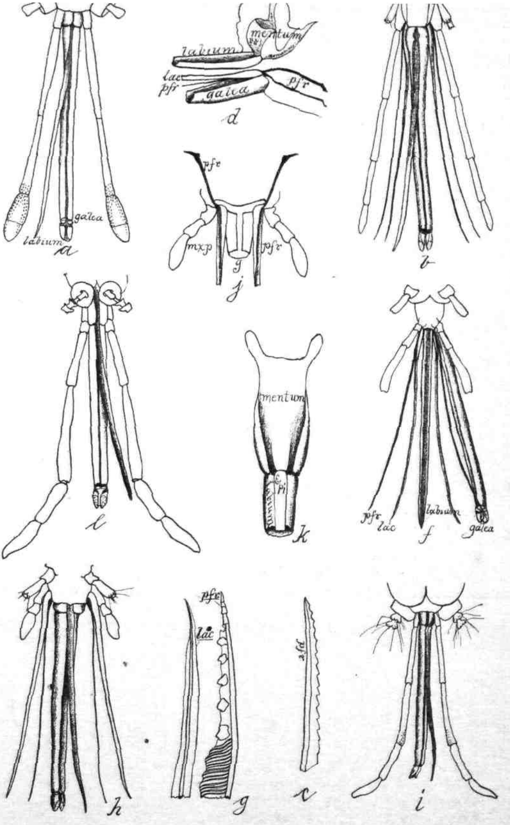


Fig. 15.

Mouth parts of mosquitoes enlarged. *a*, *Anopheles punctipennis*; *b*, same, female; *c*, tip of one of the lancets more magnified; *d*, shows how the parts issue from the head; *e*, *Psorophora ciliata*; *f*, same, female; *g*, tips of the lancets more magnified; *h*, *Culex pungens*; *i*, same, male; *j*, shows how the mouth parts are joined to the head; *k*, the mentum through which passes the œsophagus to join the mouth tube composed of the labium and epipharynx. Original.

In other words, some change has taken place in its character and it has become much more fluid.

If we examine the mouth parts under a microscope of sufficient power, we find that the proboscis or beak is merely a shield or cover for the real biting structures. It is jointed at the base and near the tip, and is open in front for its full length. The tip is not sharp or pointed, but soft and even a little spongy, utterly unfitted for puncturing muscular tissue. But the structures within this beak are quite different and fully capable of piercing the toughest human hide that occures in the State. They consist of five slender lancets, arranged in two pairs at each side of a larger central organ. This central structure is the labium or lower lip and is somewhat flattened, and grooved or channeled on the upper side. At its base is the opening into the gullet or œsophagus, and it is joined to a somewhat horny or chitinous structure, giving attachment to muscles that form the sucking or pumping arrangement, to bring food into the stomach. The two lancets on each side represent parts of the maxillæ or lateral jaws of biting insects, and they are dissimilar in appearance. One

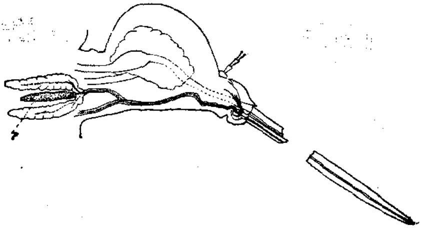


Fig. 16.

Section of the head of Culex, showing location of poison gland at P. (After Macloskie, from Howard, "Mosquitoes." Copyright, McClure, Phillips & Co., by permission.)

is very slender, almost cylindrical, and with a series of little teeth at the tip; the other is more flattened and has the tip drawn in to a thin, sharp blade, also with small teeth at one edge. These lateral lancets are piercing organs merely and assist the central organ or labium in getting through the skin. The labium has a cover to the groove on the upper surface; a very thin, flat piece, forming a continuous tube from near its tip into the œsophagus. This tube is so fine that

the blood corpuscles, small as they are, cannot readily pass through it. At the base, and just before the œsophagus, is the opening of a small tube or duct coming from a salivary or poison gland, and at the moment when the central lancet gets through the skin, a small quantity of this saliva is introduced into the wound. It is this, and not the puncture, that causes the pain, for the saliva at once acts upon the blood, breaking up its corpuscles and thinning it out, that it may be readily absorbed by the insect.

It is often said that if you allow a mosquito to finish feeding, the bite will raise no swelling and will not pain much. There is a little basis for this belief, for the poison introduced to liquify the blood is largely or entirely re-absorbed by the insect in making its meal. But if the creature is killed after injecting the saliva, the poison nevertheless exercises its specific effect, and inflammation is set up that must be dealt with by the body in its natural way. The extent and duration of this process varies in the individual.

Some persons are very little affected, and a bite creates, at worst, only a brief sense of discomfort. Often these individuals say the mosquitoes never bite them. I have seen two of the insects absolutely gorged with blood on the neck of a man while he was telling me such a tale in absolute good faith. He simply did not feel the bites. Other persons suffer severely, each individual bite causing large swellings, resembling hives. I have seen such an individual with neck and face puffed up, suffering tortures, while others in the same party were merely annoyed. There is undoubtedly a difference in attractiveness among individuals, some being much more frequently bitten than others; but no one is entirely exempt, so far as my experience goes. It is possible to become inoculated with the mosquito virus, so that the bites in time cause little or no trouble; but I have seen even natives in bad mosquito districts almost frantic in clouds of the little pests.

Nor is the virus exactly the same for each species. Sailors and fishermen along shore usually say that they don't mind the bite of the salt-marsh species; but the little black fellows in the fresh-water swamps are "the very devil." The exact opposite is said by the inland inhabitant when he gets to the shore.

The difference between *Culex* and *Anopheles* is yet more marked, and, personally, I can always tell by which I have been bitten. *Culex* bothers me very little; *Anopheles* wakens me out of the soundest sleep, and the pain has a peculiar penetrating character not easily described. I am aware that others have the opposite experience.

So, while with me the effect of a *Culex* bite usually disappears completely in a few minutes, *Anopheles* leaves a little pustule that may itch several days afterward, if irritated. The same species may also, under different weather conditions and when fasting, bite more painfully. In hot weather, when the specimens have not fed for some days, the salivary secretion becomes acrid and, apparently, concentrated, so as to cause a more painful wound.

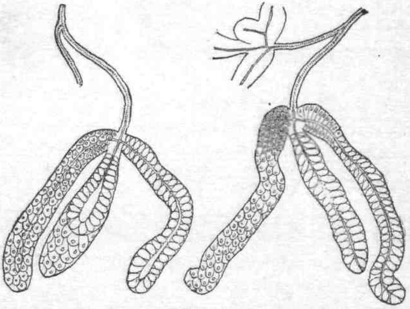


Fig. 17.

Salivary glands of *Culex* at right, *Anopheles* at left; greatly enlarged. (After Christophers, from Howard, "Mosquitoes" Copyright, McClure, Phillips & Co., by permission.)

Thus it is seen that a mosquito bite is not the same under all conditions and at all times.

It should be added that the above general description applies to the females only. The mouth parts of the males have the same general appearance, except that the palpi are always larger and better developed, resembling golf sticks in some cases. Under the microscope a much more important difference becomes apparent, and only the central lancet remains. It is not actually impossible for a male to bite, but I have never seen one do so, nor have I ever caught a male in the swarms attacking me in the field.

Remedies.

As a mosquito bite exercises quite a different effect upon different persons, so the matter of counter-irritants, or applications to allay the pain, is also somewhat individual. For most persons, the application of a drop of strong ammonia water directly to the bite will stop or materially lessen the pain. It is the remedy I use, and it has been used by many others with equal success.

Eucalyptol has no effect in my case, but acts well with some others.

Menthol is effective with many persons, and gives some relief in nearly all cases.

A drop of kerosene proves effective in some instances, but does not help me.

A bit of raw onion rubbed over the bite is almost as good as the ammonia in my case, and with such others as have tried it; but is not nearly so conveniently carried about or applied.

The best method where the poisoning is not really severe is to let the bite alone and pay no mental attention to it.

Repellants.

The cleanest and most effective repellant—*i. e.*, a material which will keep off mosquitoes—is oil of citronella. This is an extract from a grass, *Andropogon nardus*, primarily used in the manufacture of cheap grades of perfumery. The odor is not unpleasant to most persons, is quite lasting, and absolutely keeps off all kinds of mosquitoes. Protected by this material, I have slept comfortably for an hour on a seashore piazza, on an evening when everyone else was driven indoors. I have used it since 1897 on all my collecting trips, and, no matter how large the swarm of mosquitoes surrounding me in the salt or other marshes or in the woods, none ever alighted on any protected part of the body. Many others have used this material on my recommendation, and in all cases it has proved absolutely effective. It may be liberally applied on the hands and face or other exposed parts of the body, but should be kept out of the eyes. On very hot days, or when perspiring freely, it causes a slight burning sensation on the skin of the face. So much superior is this to anything else known to me that I do not consider it necessary to mention any of the many other mixtures and compounds that I have seen and used.

Fig. 18.

Upper half shows one of the cages used in studying the Cranberry Katydids; lower half shows one of the Castor oil plants at porch corner in early August. *From original photos.*

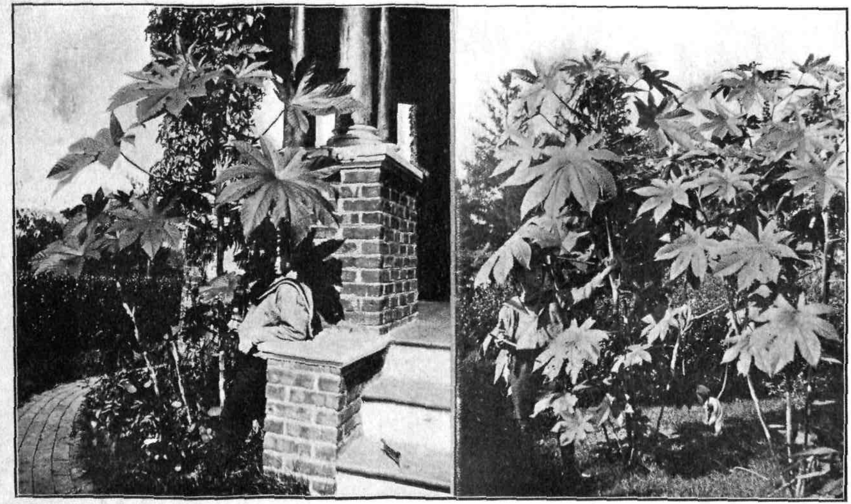


Fig. 19.

Shows Castor oil plants at porch corner and in the plot just opposite, as they appeared in mid August. From original photos.

Sometimes certain species of mosquitoes will make a determined effort to get into the house through the wire-netting screens. Not all species do this, nor do the forms that have the habit do it at all times. But I have watched a screen for several minutes, and have seen specimen after specimen work its way through into the room.

Painting the screen lightly with a brush dipped in kerosene put an immediate and final stop to this practice. Not another specimen came through the treated screen, while through the other the procession continued uninterruptedly until I had satisfied myself that the stoppage on the first screen was not due to some outside cause. Then I painted the second, also with equally satisfactory results.

Castor bean plants have been said to exercise a repellant effect, and I will not say that they may not do so in some places and against some species; but the New Brunswick brands of the New Jersey species do not mind them in the least. I have always had a little group of castor bean in my garden, and, to test its effect on mosquitoes, I planted three groups in 1901. One large group was about ten feet from the corner of my porch; a second was on the opposite side of the garden; the third was at the corner of the stoop-bench, overhanging it. Sitting on this bench, the back rested against the bean stalks and the leaves overhung the head. Yet this was a little the worst mosquito corner of the porch throughout the summer. While I will continue to plant castor beans, it will be because I like the plant, and not because of any expected effect on mosquitoes.

How Long do Mosquitoes Live?

For the present, our answer to this question must be, "I don't know!" For the hibernating species, we know, of course, that they live all winter, and, for a time, at least, the preceding fall and succeeding spring, until they have succeeded in laying their supply of eggs. Of the *Anopheles*, we know that they cannot transmit malaria unless they bite twice, at least, and live for several days between bites to permit the development of the Plasmodia. Of the *Culex* (*Stegomyia*) *tæniata*, which carries yellow fever, we know the same thing, and we know that individuals have been kept in captivity for a considerable time.

But this does not answer the question for the other species during the summer, under normal out-door conditions. There is no reason to believe that the females are not sexually mature when they emerge from the pupa, and that impregnation does not occur promptly. In

fact, there is every reason to believe that copulation takes place very soon, and that eggs may be laid a day or two thereafter. It is a general rule, though by no means universal, that when an insect has provided for the continuation of the species, its work is done, the reason for its life is gone, and it therefore dies. On the other hand, insects normally short lived often survive for considerable periods when there is no opportunity to lay eggs, life holding its own, apparently, until its continuance is assured.

Based on these considerations, it would seem that the life period of an individual mosquito is an undetermined quantity; that in favorable seasons, when there is plenty of moisture and eggs can be promptly laid, a week might measure the period; but in times of drought individuals might live as much longer as was necessary. So, if for any other reason eggs could not be deposited, life would be unusually prolonged. This point applies especially to the shore mosquito, which, breeding only in salt water, yet swarms at times in localities miles away from any possible breeding-place. Such specimens would live for some time—two or three weeks at least—and this is indicated by the fact that in places where mosquitoes come in rarely and do not breed naturally, the pest remains bad for a week or ten days, and then gradually disappears.

This is a point that requires further observation and experiment, for of most of the species we know nothing definite.

THE SPECIES OF CULEX.

Heretofore facts of general application to all mosquitoes or to some general class of species have been brought out, and it becomes necessary now to speak more particularly concerning two of the genera and a few of the species. Other genera occur, and will be mentioned later, but the two best-represented genera are *Culex* and *Anopheles*.

The genus *Culex* contains all the common, every-day mosquitoes that occur almost everywhere, more or less abundantly, throughout the State. They are moderate or small in size, with long, but not awkwardly-long, legs, unspotted wings, and, in the female, very short palpi or mouth feelers. The great majority of all the mosquitoes seen by the average individual are species of *Culex*. Just how many species or kind are to be found in New Jersey I cannot yet say. I have bred seven species during the past season, and have taken at least three, if not four more, so it is certain that we have nearly a dozen, at any rate.

These differ much in their habits, the places selected for breeding and in other characters. Some are practically confined to the woods and are rarely found in houses. Even when the woods come within a few hundred feet of the house they do not seem to care about leaving them. Such species breed in springs, in road pools through swampy, cold ground, in spring-fed ditches and the like. Others breed anywhere—in rain barrels, road puddles, even in cesspools. Such are usually house mosquitoes, and form the bulk of the

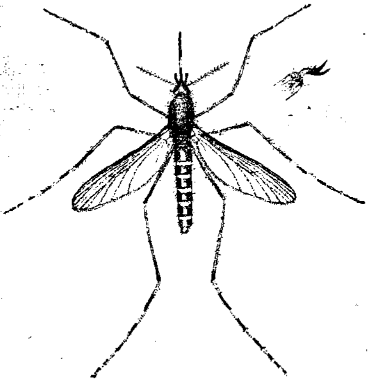


Fig. 20.
Culex sollicitans—the salt marsh mosquito: female, enlarged; toothed tarsal claw at right, yet more enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

locally-bred examples that occur in the inland towns. To show how readily they breed, it may be said that in the botanical laboratory a battery-jar containing plant specimens in water was found to be swarming with wrigglers. In one of the College fraternity houses the waste to the shower bath became choked, and a little puddle remained on the depressed floor area, awaiting the leisure of the plumber to make repairs. Long before he came the little puddle was swarming with larvæ, and prompt measures became necessary. In fact, there is no place so unlikely that it may not serve as a breeding

place for some *Culex*, provided only there is water ; it may be an old tin can or a hollow in a tree trunk—all are equally acceptable.

Yet another species breeds only in salt water, though the majority, if not all the others, are confined to that which is fresh.

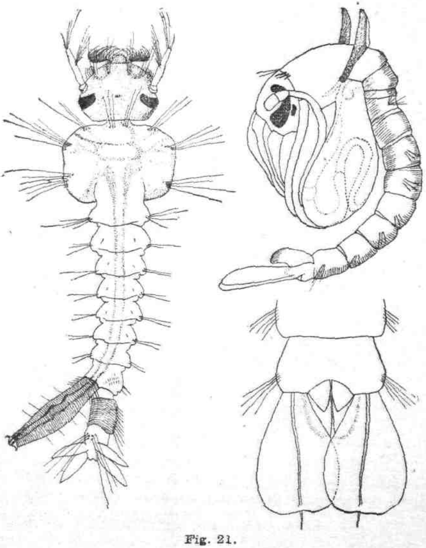


Fig. 21.

Larva and pupa of *Culex pungens*, enlarged ; with anal flaps of pupa yet more enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

I have several times referred to "wrigglers" as mosquito larvæ, and this term is especially appropriate for those of the genus *Culex*. Mosquito larvæ are odd-looking creatures, with large head and fore-body, a slender abdomen, and a long or short tube-like structure on the penultimate segment, through which it gets its supply of air. Figure 21 illustrates the appearance of such a larva. Though it lives altogether in the water, the larva is dependent for its supply of oxygen

upon what it can get from above the water surface; hence this anal breathing-tube is a very important structural character. It varies in the different species, but always has essentially the same functions. The normal position of a mosquito larva in the water is head down, anal tube at the surface. When disturbed, it gives a quick, jerky start that sends it to the bottom, where it remains until matters quiet down or until the lack of air forces it to the surface. Then it makes its way up by a series of jerky or wriggling movements that have given it the common name. The mouth parts consist largely of a pair of brushes, which are kept in almost constant motion, serving partly as a means of locomotion, and partly to create a current which brings to the mouth opening the microscopic organisms upon which it feeds. Mosquito larvæ are in their natural functions scavengers, and their mission is to do away with some of the forms of organic life that would otherwise cause putrid conditions. There is, consequently, a good good reason for the existence of the mosquito, and, if the adult is often a nuisance, the larva has a claim to our consideration.

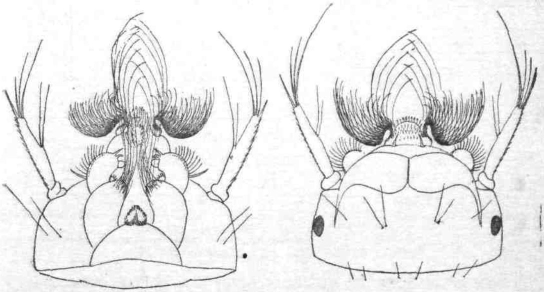


Fig. 22.
Head of larva of *Culex pungens*: from below at left, from above at right; greatly enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

From the sides of the larva or wriggler come little tufts or groups of hairs or spines, which are more or less branched or otherwise modified, so as to form convenient means of recognizing the different species.

Life History.

In a general way, all the species of *Culex* have the same life history. The winter is, or is believed to be, passed in the adult stage. Of some we know that this is so; concerning others it is a matter of belief, based upon general principles. When the warm weather sets in fairly, the few examples that have succeeded in passing safely through the dangers of the winter seek a place to oviposit. Only the females live over from the year before, and they make no unreasonable demands; any bit of water in which there are not too many enemies will answer.

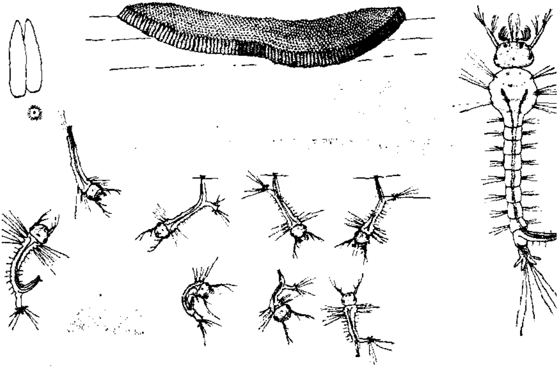


Fig. 23.

Culex pungens: egg mass, with enlarged eggs at left and young larvæ below; enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

Eggs are laid on the surface in somewhat oval, concavo-convex masses, loosely termed "boats," each of which is the product of one female, and contains from 200 to 400 eggs. A boat of this kind is about three-sixteenths of an inch long, and rather more than half as wide, but is not regular in outline. Individual eggs are about .03 (three one-hundredths) of an inch in length, slender, a little pointed at the tip and broader at the base. In color the mass is a dirty gray, tending to blackish as it grows older. The egg-stage is a short one, varying a little as the temperature is high or low. It ranges from

twenty-four hours to three or four days, and then the young emerge from the base or broad end of the egg, which rests upon the surface of the water. The larvæ are thus brought naturally into the medium in which they are to live, and the period of this larval-life is also largely a matter of temperature. In midsummer, when the water is warm and the food-supply abundant, from six to eight days is enough to bring full growth, with a minimum of ten days for the entire life cycle. When full grown, the larva changes to a pupa, which is a peculiar, bull-headed creature; the head and thorax with its wing cases forming an enlarged structure, the abdomen slender and curved beneath, terminating in two broad, somewhat leaf-like appendages. At about the place where the thorax and abdomen join, there is a pair of "horns," or slender, curved tubes, through which the pupa breathes, and these rest normally at the surface. The pupa is lighter than water, and, under ordinary conditions, floats, requiring no effort to keep it in place. If disturbed, it moves down and away by irregular, jerky motions; but rises rapidly to the top as soon as these cease.

The length of the pupal-stage also varies, according to the season, from less than twenty-four hours to several days, and the species themselves vary in this particular.

These general statements apply to all the species of *Culex*, so far as we know, and may be assumed for those forms hereafter mentioned, except where otherwise specified.

It may be added that breeding continues far into the fall. Mr. Brakeley has taken larvæ and pupæ out of pools that have been ice-covered, and I have taken them from a pail that had been covered with one-quarter inch ice, breeding *pungens* from them.

THE SALT-MARSH MOSQUITO.

Culex sollicitans Wlk.

This is the common species that lives along the seashore and brackish marshes along the coast. It often occurs in swarms sufficient to make life a burden, and has absolutely depopulated and caused the abandonment of otherwise well-situated seashore resorts or colonies. It is easily recognized by its generally gray color, the legs prominently banded with white, and the beak or proboscis with a distinct white band at its middle. The sides of the body beneath the wings are black, and this is an easily-noted character. The abdomen is banded with yellowish-white scales, and a line of such scales runs

down the middle; so, with all these points, which are not combined in any other New Jersey species, there should be no difficulty in recognizing this mosquito wherever it may be found, along shore or inland. I say inland, because, though it breeds only along shore, as is shown in the next section, and the larva occurs nowhere else, the adult is by no means so limited. It is by far the most abundant species throughout South Jersey, and at certain seasons is the only one. It extends from the coast to the Delaware river, to Philadelphia, and even further north in Camden county. It extends inland along all the larger streams and over the meadows at the mouth and along the valley of the Hackensack and Passaic rivers. It is the dominant species at Newark and Elizabeth, and at times the dominant species at New Brunswick. It extends to the base of the Orange or Watchung mountains, but does not get into them very much. Yet it has been taken at Morristown, and is not uncommon at Paterson. I have not had it from Bound Brook, Somerville, or points north and west of that region, and it is usually rare in the higher regions, even in the southern counties. Almost invariably, the localities where mosquitoes were said to be rare or wanting owe their exemption to the absence of this species. Invariably, where it was *reported that mosquitoes were sometimes bad, but did not often* come, the culprit turned out to be this form. I drove through the pines for miles several times this season, when the carriage became filled with mosquitoes, and all were *sollicitans!* On cranberry bogs, twenty miles from shore, not in one place only, but in a number of them, the millions of specimens were all of this one type. On an evening in July I spent half an hour on the platform of the Newark station of the Pennsylvania railroad, waiting for a train, when mosquitoes were in such swarms that no one had more important work than slapping at them, and all were this form. For two weeks or more the only species that I could find around my porch in the evening was this very one! More than half of all the specimens received from health officers in South Jersey are of this species.

Briefly stated, this is *the* Jersey mosquito, and were it wiped out of existence over 60 per cent. of all the specimens in the State would be accounted for. Indeed, in some regions this is practically the *only* species, so that exemption from its visits would mean an almost total absence of mosquitoes. In most of the others the residue would be so small as to be either unnoticed or to cause but a trifling inconvenience.

The economic importance of the species is, therefore, obvious, and the first question must be as to how and where it breeds.

BREEDING PLACES.

Concerning the breeding-places of this seashore mosquito, the experience of the season seems to prove positively that it is confined to brackish or salt water. I have hunted the larvæ in fresh-water districts where adult females occurred by the million, and failed absolutely to find even a single specimen. In the pines and about cranberry bogs, where without citronella it would have been torture to collect, I gathered larvæ in numbers, but never of this species. In my breeding-pails at New Brunswick every species that was found flying was bred except—*sollicitans*. On the shores of Barnegat bay, on meadows covered with fresh water in pools and puddles, where it seemed as if *sollicitans* was the only species, and was certainly the only one that occurred in swarms, larvæ were found in great abundance—but never *sollicitans!* So plentiful were the larvæ that random dippings with a two-ounce beaker would give from a dozen to twenty or more at each dip, but none were *sollicitans*. At Anglesea, where I gathered in larvæ of *sollicitans* from every brackish puddle and bred them, none of this species could be found in fresh water. On the meadows near Elizabethport Mr. Dickerson spent parts of three days hunting mosquito larvæ. He found them, of course; but not until he got into distinctly-salty water did he get *sollicitans*. It seems almost incredible that the immense swarms that covered miles of South Jersey—all females—should die without reproducing their kind, while water in abundance was everywhere. Yet such is undoubtedly the fact, for neither I nor any of those who have collected for or with me this season has found a *sollicitans* larva in fresh water.

In brackish and salt water they occurred everywhere. At several points along shore I collected at different times during the season, and wherever I found a salt-water puddle in a road, in a mud flat, or in a partly-filled ditch, there were larvæ in swarms. Here there was no difficulty in finding male adults, and here was oviously the home of the species. Not only in puddles and ditches, of course; there are everywhere on this coast region immense flats, which are covered only at unusually high tides or during storms, and when these tides recede every hollow and hole is filled with sea water, which evaporates very slowly. Here are the ideal conditions, and here these swarms are bred that are afterward carried miles away. The water evaporates, and only the deeper holes remain—absolutely crowded with wrigglers. A shower or a rainy day brings a fresh supply of water, which becomes salty from the sediment on the surface or from

the concentrated liquid remaining, and favorable breeding conditions are again restored. In this way was bred the immense swarms which during 1901 drove visitors from many a point and caused loss and annoyance, if not positive suffering, to the permanent residents.

So that it is salty, it does not seem to matter much to the larvæ how salty the water may be. During the latter part of June I collected a lot of larvæ of all sizes from various puddles at Anglesea, and carried them alive, in the water in which they had lived, to New Brunswick. At the same time I handed a bottle of the wrigglers to Dr. E. G. Love, of New York City—a chemist by profession, an entomologist by inclination—and asked him to determine the percentage of salt as compared with sea water. Another sample was handed to Mr. John P. Street, one of the chemists at the Experiment Station, with the same request.

Mr. Street reported the salt in the sample analyzed by him at 122 per cent., compared with sea water at 100 per cent., and Dr. Love made it 123.8 per cent. on the same basis. As the samples came from different pools, the percentages are slightly different, but both show a salt content almost one-fourth greater than sea water. That they do not need this large quantity is shown by a series of experiments made by Dr. Love later in the season, on which he was good enough to report to me as follows, the account being summarized, except where quoted : Larvæ were taken August 3d, 1901, from a tide pool on a salt meadow at Miller's Place, Long Island. This meadow has underground springs of fresh water, so that the newly-rising tide was more or less diluted. The pool was left very nearly dry at ebb, there being sometimes barely enough water present to keep the larvæ in a moistened condition, and not sufficient to enable them to move about. The larvæ were all above half-grown, some near pupation, and some adults emerged four days afterward.

"My object in the experiments was to determine how strong a solution of salt the larvæ of this species could stand, and the following figures of salinity are calculated on the basis of that of sea water being 100.

"The different solutions were prepared by adding varying quantities of a salt solution to known quantities of the original water. The salinity of the solutions was afterward determined by analysis of the original water and the salt solution used, and a simple calculation."

The analyses were not made until after the conclusion of the experiment, and it was not known that the water in which the larvæ

were taken had less than half the salt content of normal sea water. Normal sea water was assumed in planning the experiments.

"The first three solutions which I used, and upon which I mainly depended, were, therefore, much weaker than I supposed, and the experiments made with the first and second really added nothing to what we already knew, inasmuch as they were not as strong as the sample from Anglesea. Between the strongest of these and the next one (still stronger) there is, unfortunately, quite a gap. I will give you the figures as I have them, and you can make such use of the results obtained as you wish:

"The original water contained 44.5 per cent., and I call it No. 1.

"No. 2 contained 71.6 per cent. of sea water.

"No. 3 contained 97 per cent. of sea water.

"In these three the larvæ were very active. Several pupated on the 6th. On the 8th many had emerged, and within a few days all had done so.

"Then comes the Anglesea water with 123.8 per cent.=No. 4.

"No. 5 contained 143.3 per cent.

"There was no marked difference between this lot and those in weaker solutions.

"No. 6 contained 254.4 per cent. It is unfortunate that there was not at least one solution between this and No. 5. At the same time, as a matter of practical interest, the experiments should have been made on the eggs and young larvæ, and an effort made to determine what percentage of eggs, hatching, survive through the various stages to pupation. It seems very probable that the solutions which do not kill the half-grown larvæ would have a much more destructive action on the larvæ in the early stages.

"The larvæ placed in solution No. 6 became very sluggish at once and were dead within a few hours. As the gravity of the solutions (from here on) increased, the larvæ were unable, apparently, to maintain a perpendicular position in the water, but lay upon the surface. This was probably due in part, and it may be entirely, to the fact that the water was killing them and they had not much vitality, although they moved about more or less. The stronger solutions had, practically, the same effect as No. 6, but, naturally as the strength of the solutions increased, the larvæ died sooner. One solution, about six times stronger than sea water, killed them in two to three hours.

"Some of the larvæ were removed from the original water and placed in Croton, in which they flourished as well as in the original

water. Another lot was placed in distilled water after passing them through a dish of the same to remove any particles which might be carried with the larvæ in the first skimming. They did as well in this as in any of the lighter saline waters, but the effect might be quite different and undoubtedly would be if the larvæ had been young.

"I also put a lot of the larvæ and another lot of pupæ on wet sponges. There seems to be no difficulty in the pupæ living through this short stage under these circumstances, but the larvæ are not able to pupate."

The latter observation makes it almost certain that if the insects can reach the pupal stage the water in the puddles in which they live may evaporate completely if only the surface remains moist.

The account also shows that under certain conditions the larvæ occur in tide water, which is certainly not the rule. But the actual rise and fall here, as Dr. Love informs me, was only a couple of inches. About as good places for larvæ as can be found are those salt meadow areas where the railroad companies have cut off the sod for their embankments and dams. These areas form shallow ponds, which persist from one spring or storm-tide to another and bring forth mosquitoes continuously.

Ordinarily, all areas over which the tide ebbs and flows freely are free from mosquito larvæ. In such areas fish come in with the tide, fiddler crabs live in the mud and a variety of shell-fish, snails and the like find a permanent home. Here no mosquito larvæ can maintain themselves, even in pools, which are never entirely drained at low water. Little fish gather here as the tide recedes and no wriggler could survive for an instant.

It is again emphasized that only in salty water, and under conditions such as I have described, can this species breed. The importance of this limitation will appear when the question of dealing with the insect comes up; for it both limits and directs the character of the work to be done.

I have a large lot of notes and observations relating to specific breeding grounds along shore; but there is no space here for the detail nor necessity for the purposes of this report.

How Do the Insects Spread?

Having now shown that *Culex sollicitans* is the most common and troublesome species throughout a large part of the State, and also that it breeds only in salt water, the question naturally arises, how do the insects get so far from the breeding places, and what becomes of them when they are twenty to thirty miles away from the nearest point where their larvæ may live? Further, it should be determined whether the coming in is continuous or intermittent—dependent upon some necessary combination of meteorological conditions or only upon the volition of the insects themselves. It would be too much to claim that these questions can be definitely answered as the result of the work done this year; but the probabilities have been outlined and the lines of future investigation have been fairly well indicated. I may premise that up to the present season I had not believed in any migration or long mosquito journeys, and Dr. Howard so quotes me; but my last season's experience convinces me that I was in error.

First of all we may eliminate the human element entirely, from a practical standpoint. Nothing that man has done or is doing favors the spread of the insects, though it may check or retard it. Dr. Howard thinks railroad trains are responsible for some carrying from one region to another, and he is undoubtedly right as to the general proposition. A few female *C. pungens* or other breeders in fresh water, carried from a coast city to the Catskills, might easily start a colony or a series of colonies where none were before. But this does not apply to our shore species. A dozen specimens, carried from Jersey City to Somerville, would be only a dozen specimens, and would remain that many only, since they could not breed when they got there. Furthermore, there are a large number of trains daily between Jersey City, Newark and Somerville, and if trains carried any large numbers Somerville would be pretty well supplied with *C. sollicitans*, whereas, in fact, not a single example has been found there during 1901. And it has not been because there were no *sollicitans* at Newark or in the trains at that point. *Sollicitans* is not by preference a house mosquito, and while it will get in occasionally, or even abundantly when there are many of them about, it is easily kept out, and will get out of its own accord if given the opportunity.

During the past summer I have been on trains running from the shore to Philadelphia a great number of times, and almost invariably, while crossing the meadows, a number of mosquitoes came into the cars. But as we proceeded they made their way out again until,

long before we were anywhere near Camden, not a specimen remained. On the trains from Toms River, which I boarded several times at New Lisbon, Hanover Station or Browns Mills, there were always a few *sollicitans;* but most of those disappeared before we reached Pemberton, and none ever got to Mount Holly within my observation. I have said that it is not a house mosquito by preference, and for that I have abundant evidence. Not a mosquito got into my house at New Brunswick, while *sollicitans* was the dominant or only form, though the garden was full of them, and though sitting on the porch meant using some repellant to secure comfort. In fact, not one of the specimens that I saw indoors during the entire season was of this species.

Of the house captures sent me by Mr. Brakeley from Lahaway, not one was *sollicitans*, though there were "bushels" of them not many yards away. I had some of my board of health collectors send me separately, specimens taken in rooms and specimens taken outdoors and it was rare that the salt species occurred in an indoor bottle. There are plenty of them in the houses which are right in their breeding places, because they are everywhere in such cases; but even at Anglesea, where *sollicitans* simply swarmed on the hotel porch, the only species in my room was *pungens.*

A ride from Atlantic City to Somers Point during mosquito season is an interesting experience. None are in the cars at the start, nor, if there is any wind at all, during the ride across the meadows; but at Pleasantville they begin to come in, and as the ride extends along the edge of the meadows they increase in number until Somers Point is reached. On the return trip the reverse experience is encountered. Most of the specimens that entered the car on the coming trip have made their way out; but as soon as the train starts and stirs them up they begin coming in again until the edge of the meadow is reached. While crossing this most of them disappear, and the train reaches Atlantic City practically free from mosquitoes.

Having eliminated the human element, there remain for consideration voluntary flight on the part of the insects and their involuntary transport by high winds. The latter alternative may be also eliminated, for it is the universal experience that the insects do not fly in a strong wind, or if they do, they keep to shelter so far as possible and do not rise high enough to be caught and carried away by the gales. In fact, under ordinary conditions, voluntary flight is never high above the surface, and this seems reasonable when we consider

the feeding habits of the species. All the food occurs near the surface.

Do the insects, then, migrate voluntarily? It would be too much to say so; but, at least, it is certain that the males take no part in it, and that the females certainly do place themselves in a position to be carried by a good breeze for long distances. Damp or wet weather seems preferred, or may even drive the insects out of their native heath; at all events when the cause acts it affects multitudes of individuals that form swarms of great extent. So far as known, these flights occur only during the night. It is not a wind from a certain direction that is the inspiring cause, for swarms are carried out to sea as often as inland, if the statements of captains of coasters and fishing boats can be believed. Fifteen miles out they have reached a fishing fleet at anchor and invaded every vessel; to that I have the positive statement of two of the captains who were seen at separte places and separate times, both narrating their experiences in this direction at my request. It is common knowledge that, whereas, Barnegat bay is ordinarily quite free from them, occasionally a light land breeze will bring clouds to the center or quite across to the shore resorts. A land breeze is therefore dreaded, because it "brings mosquitoes," while a sea breeze, on the contrary, "drives them away" or at least discourages flight, for specimens remain some time, away from the immediate beach.

Berlin, Camden county, is about forty miles from the sea, and reported to my inquiries that mosquitoes were very plentiful at times; that they came with a south wind from the shore and that their duration depended on the winds holding true. A vial of specimens sent me when one of these shore winds brought the insects proved them *sollicitans.*

Mr. M. C. Lohsen, of Belford, Monmouth county, wrote me on this point as follows: "I am convinced that the mosquito is migratory; we have them most after a long southerly or southwesterly wind and less after a northerly or easterly wind. One case in point: one night (we had no mosquitoes) I heard them in the air like bees overhead, but could not see them. They must have settled during the night, as next day we were almost smothered with them. Then I have seen them out in the bay in years gone by, everything they could alight on being alive with them. It was only last night that the clammers, who work four to five miles from shore, reported them in swarms off shore. They also reported speaking to a party on a fishing yacht anchored near Romer Shoals, that they [mosquitoes]

invaded their yacht during the night previous and made sleep impossible."

Dr. W. G. Chamberlain, of New Egypt, Ocean county, which is about twenty miles from shore, sent me this species, and in reply to my letter advising him of that fact he states that he had "always thought these mosquitoes were from the shore for two reasons: (1) They don't bother us unless we have strong south or southeast winds at night for several days at a time; (2) they are *so* hungry."

I might cite other reports without adding anything new, but will content myself with two cases that came more particularly under my own observation. Early in spring I spent a few days at Lahaway hunting mosquitoes; at that time *sollicitans* was absent and none of the larvæ taken were of this species. At short intervals thereafter I received specimens captured in the woods and others taken on the bogs or dams. None of these was complained of as unusually abundant. But suddenly, after a few days of southeast wind in midsummer, came a bottle of *sollicitans* with word that I could have a bushel of them if need be, and loud complaints that they made outdoor work a burden.

At about the same time, or a little later, the Browns Mills district was invaded in the same way, and when on August 19th I drove with Mr. J. J. White from New Lisbon to his bogs near Hanover Station, a distance of about six miles, *sollicitans* appeared in swarms as soon as we got well within the pines. Mr. White and his daughter, Miss E. C. White, agreed that two weeks previously nothing of the kind existed. I have already recorded the fact that I found no larvæ of this species anywhere about the bogs where the adults were so numerous.

As the result of my observations, supplemented by the information obtained from a large number of individuals, I conclude that *Culex sollicitans*, the salt marsh mosquito, is to an extent migratory, using that word rather loosely, for it is not a real migration; that the direction of flight is not within its control, but depends upon the wind; but the impulse to rise in masses and float with the wind is in the insect, and in so far as there is an obedience to this impulse, the flight is a voluntary one. The distance to which this migration extends is not yet definitely determined; 40 miles certainly at times; 20 miles very commonly. The specimens taken at Philadelphia may have come up the Delaware river and may have been bred much nearer the city than the distances above mentioned.

We do not yet know what factors determine the flight from the

breeding grounds nor how long the insects remain afloat. A five or six-mile breeze might carry them a long distance during the night. It would be also, at least, interesting to know whether, after one flight, the same swarm ever started on another. In fact, there is a series of problems yet to be worked out concerning this common species.

It is in place to add that the conclusions above stated apply only to *Culex sollicitans*, and may be entirely inapplicable to any other species.

THE HOUSE MOSQUITO.

Culex pungens Wied.

This species is a close ally of the European *Culex pipiens* L., and probably the same species ; but as this matter is at present somewhat uncertain, the name used by Dr. Howard is employed here.

In calling it the "house mosquito" I do not mean to assert that it is confined to an indoor habit ; simply that the great majority of all the specimens received as taken indoors or observed by myself are referable to this species. It is also the only form which I have ever seen in the rooms or cellar during the winter. In warmed rooms or houses it continues active all winter and may even breed. I have been bitten, in Philadelphia and New York hotels, in January, and the culprit, when hunted down, was always *pungens*.

It is difficult to describe this insect because it has no strongly-marked peculiarities. It is of medium size, dirty-clay yellow in general color, and has the abdomen obscurely banded. The legs are not banded, and the beak has no white ring or band. It varies somewhat both in size and in general color, some specimens being of a decidedly light yellow. Examples taken by Mr. Brakeley with the mass of *Anopheles* in his cellar, were almost cream-colored, so light in tint were they. It is probable that age has something to do with this, and that the darker examples are such as have lived some time.

This is the species referred to on a previous page as breeding in all sorts of unexpected places, citing the botanical laboratory and the waste water from a shower bath as examples. Its larvæ have been also found in a neglected aquarium in which there were no fish, and in tin cans and other localities of similar degree. Most of the mosquitoes bred in my back-yard pails were of this species, and Mr. Brakeley sent me a great mass of them as wrigglers taken from a rain barrel. Mr. Dickerson found the larvæ in sunken lots in Newark, where they were dumping garbage, and in an old cistern at Morristown. Mr. M. S. Crane found the larvæ in cesspools and in liquid

manure, and Mr. Brakeley found them in filthy pools of a creek receiving city sewage. There is no place so nasty that this larvæ will not live in it, provided only that it must be liquid. In some of the pools in which they occurred the surface was so covered with a greasy scum that it seemed almost incredible that the breathing tube could pierce it.

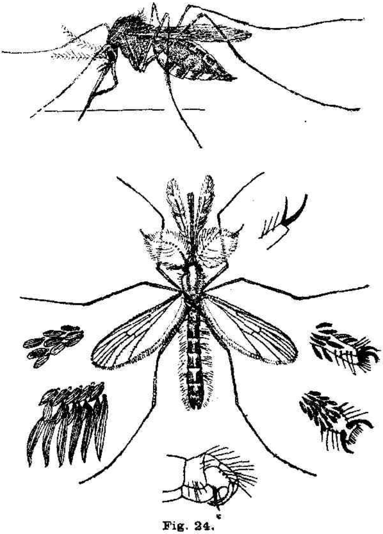


Fig. 24.
Culex pungens: female, with distended abdomen, above, male below; enlarged; structural details of male yet more enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

The larvæ of this species are shown at Fig. 21, and are recognizable by their generally white color and the rather long, stout breathing tube, which is a little enlarged or thickened in the middle. Having said where the larvæ have been found, it should be added that they have not been found by me in woodland springs nor in cold, running water.

Next to *sollicitans*, this is the most common species occurring in the State, but breeds under altogether different conditions. The egg boats and pupa are as has been already described, and are represented in Figs. 21 and 23.

As bearing on the indoor habit of this species, Mr. Brakeley made a series of observations on the specimens seeking shelter in an outhouse at Bordentown. During July 137 specimens were taken, all *pungens*, and 24 was the greatest number found on any one day. During August 271 examples occurred, and 43 on August 18th was the greatest number found on any one day. Both sexes were taken, the females in great excess, and they did not breed in the outhouse —that was positively determined. They simply resorted to the place for shelter, and it affords a good illustration of the domestic habits of the species.

Other Species of Culex.

Several species of *Culex*, other than the two already mentioned at length, occur in the State, but not in numbers sufficient to make themselves obtrusive. Possibly *C. cantans* may be an exception to that statement, and this resembles a very stout, more bristly *pungens*. I have bred it in pails and have collected it at South Orange.

Culex confinis has been sent me in the larval stage by Mr. Seal, of Delair, and I received a few adults from Lahaway. I think there may be some in bottles from some of the health officers, but this is not a common species and seems to be confined to woodland localities. It has a banded beak and is a large, unusually dark species.

Culex territans is a small species, which looks blacker than the others, and has slender, black legs. The abdomen is narrowly white-banded at the posterior edges of the segments, the other species having the white bands at the base. The larva is a white wriggler, with a large, square head, a long, slender breathing tube, and this I have found mainly in meadow puddles or in running water. It is a much more delicate looking larva than that of *pungens*. The adult is common enough, but seems not to be a house mosquito. I have not taken it as such myself, nor has it been sent in to me by any correspondent among the indoor captures.

Culex stimulans. This is a brown or blackish mosquito of moderate size, with the tarsal segments white-marked at base. The abdomen is rather conspicuously marked with white bands, which tend to become incomplete, and these characters indicate the species. The larvæ have been found on the Elizabethport meadows, at Anglesea and

near Newark—always in fresh water and seeming to join the breeding places of *sollicitans*. In fact, at Elizabethport, both species may breed in the same pools, as the water becomes salty by a storm-tide or fresh by the constant addition of stream-water coming in. I have never found this as a house mosquito, and it is not one of those to be counted as troublesome. It does not breed so generally as *pungens*.

Culex canadensis has the legs banded, the tips and bases of each foot-joint being narrowly white. This is a woods mosquito almost exclusively, and I have it only from the pine districts. The larva is very dark, almost black in color and breeds in woodland springs,

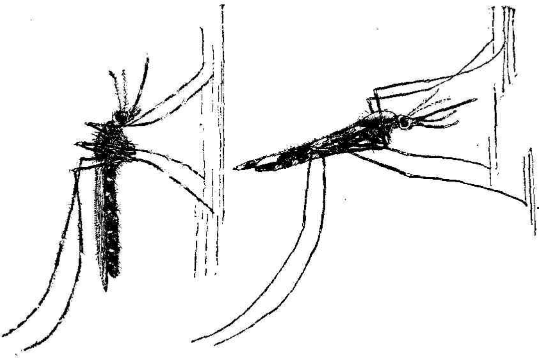


Fig. 25.
Resting positions of *Culex* (at left) and *Anopheles* (at right), enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

road puddles and ditches—always in cold water, apparently. Mr. Brakeley informs me that the wrigglers were yet active during the first week of November, and that on the 10th he found half-grown examples. This is also an innoxious mosquito, which I have not had as taken in the house anywhere. It bites readily enough when its haunts are invaded, but will not seek prey even a short distance off.

Culex tæniorhynchus is like *sollicitans*, but does not have the band of whitish scales down the middle of the abdomen. It also breeds in fresh-water pools near the seashore, and I have it from Anglesea only.

This ends the list of named forms that have been bred by me. It

may be that I have one or two others, but it has been impossible to determine them.

I have also taken several species which are not known to me in the larval stage. They are comparatively rare and need not be considered from the economic standpoint at all. So far as named they are *Culex triseriatus*, *Culex impiger* and *Culex perturbans*.

THE SPECIES OF ANOPHELES.

As compared with the mosquitoes of the genus *Culex*, the species of *Anopheles* are larger, more slightly built, with longer, more sprawley

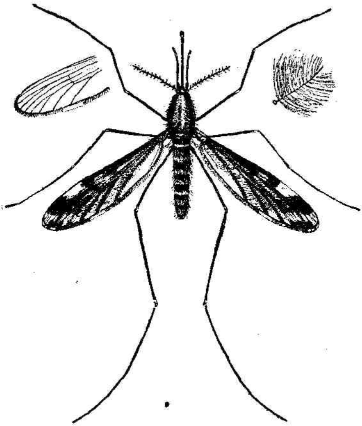


Fig. 26.

Anopheles punctipennis: females, with male antenna at right and wing tip, showing venation at left, enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

legs, and narrower, longer wings, which are laid closely over the back when at rest. The latter are also more or less spotted with black, our most common species having them very prominently ornamented. Comparatively speaking, the head seems narrower and the proboscis much longer, which is due to the fact that the palpi or mouth feelers

are as long as the beak itself and give it greater prominence. Three species occur in New Jersey, of which *A. punctipennis* is the largest, best marked and most common. Unless otherwise mentioned, all general references to *Anopheles* or malarial mosquitoes should be taken as intended for this species.

Anopheles maculipennis is decidedly smaller and the wings have only two obscure, blackish spots on each. It is an inconspicuous gray species, easily overlooked as a member of this genus. It is much less abundant than *punctipennis*, take the State as a whole, though locally it seems to outnumber the other species.

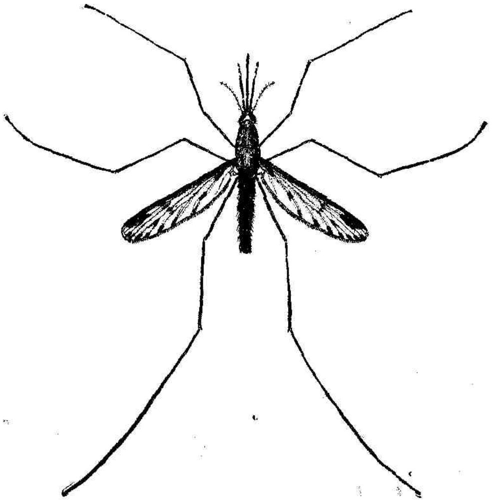


Fig. 27.
Anopheles crucians, female, enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

Anopheles crucians is very rare in New Jersey, only one specimen from Ocean county having come into my hands thus far. It is common in Delaware and southward, and I have little doubt it will

be found locally in some numbers in our State when the Cape May region is thoroughly explored.*

Besides the characters above mentioned, the species of *Anopheles* are readily recognizable when at rest by the fact that the head points to the surface upon which they alight, between the anterior and middle pair of legs, and the body extends obliquely outward at an acute angle to the resting plane. In *Culex* the body is held parallel to the plane of the resting surface, and the head does not point to it. It is surprising how quickly this character will be appreciated when it has been once seen, and even at a distance the difference is quite marked. A reference to figure 25 will make this point clear.

Life History.

So many investigators have been at work during the recently past years that the life cycle of *Anopheles* is fairly well known, and the brief account here given is partly a compilation, supplemented by personal observations made by me or by my correspondents. The matters of breeding places, spread of the insects in the State and places for hibernation are originally treated.

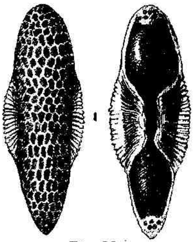


Fig. 28.

Egg of *Anopheles maculipennis*, from below at left, from above at right, greatly enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

The species of *Anopheles* make no egg-boats, and do not in any way fasten the individual eggs together. They are laid singly on the sides and loosely grouped, so that they float in little masses on the surface, among the vegetation in which they are laid. From 50 to 75 seems to be an average for such a mass, though there may be either more or less. Sometimes, indeed, a larger mass is broken into fragments and small groups of five or six, or even a less number are formed. The eggs are elliptical in shape, the ends pointed, though not quite alike, and at first view the color is black. Seen under the microscope, they are rather prettily marked and sculptured, the upper side being almost cov-

*Since the above was written Mr. Kotinsky informs me that he has taken it at Woodbine, Cape May county, and Dr. H. G. Dyar that he has it from Billport, Long Island.

ered by a clasping membrane, which comes over from the side. Figure 28 will give a good idea of the egg of *A. maculipennis*, and it need only be added that the actual length is about three one-hundredths of an inch.

The eggs hatch in about forty-eight hours, and the larvæ, when they first become readily recognizable, are black or blackish, marked with white or whitish spots and bands—"speckled-backs," as one correspondent terms them. They vary greatly, and no two seem to be

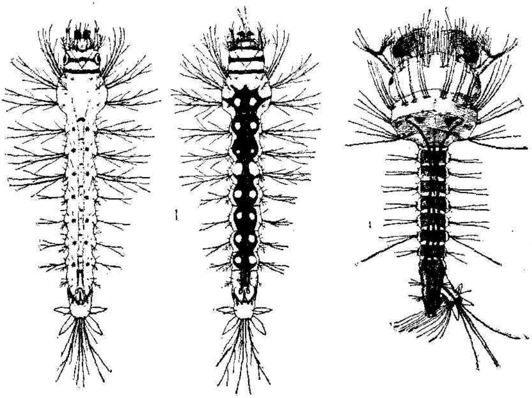


Fig. 29.
Half-grown larva of *Anopheles maculipennis* at left and center, same stage of *Culex pungens* at right, for comparison; much enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

entirely alike. At this stage they float anywhere on the surface of the water, usually with the head toward the center of the stream or pool, and feed on whatever comes in their way. My experience has been with *punctipennis* chiefly, and this will attack and eat its fellows if any shows an inability to hold its own. Unlike the larva of *Culex*, that of *Anopheles* floats on the surface of the water and does not go beneath it unless seriously disturbed. There is a very short anal breathing tube, and, altogether, the larva is quite different in appearance from its ally. Its habit of surface feeding enables it to live in

shallow water, at the edges of pools and among masses of floating vegetation—even over floating or partially submerged leaves, where it is safe from most aquatic enemies. As the larva increases in size it usually loses its speckled appearance and becomes more uniform, ranging from gray to black in one direction and to bright green in the other. Mr. Seal considers this a protective character, and shows elsewhere that there is a direct relation between the color of the larva

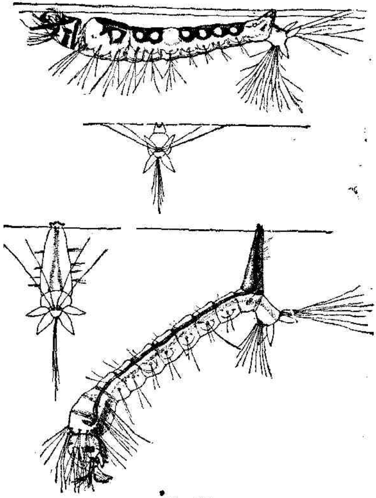


Fig. 30.

Larva of *Anopheles* (upper) and *Culex* (lower), showing comparative positions at surface of water; enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

and its habitation. It should be added that the head of this larva is unusually movable and can be completely rotated; in fact, the larva makes rather a practice of feeding with the bottom of its head at the surface of the water, while it floats otherwise naturally, back up.

The larvæ of the two more common species resemble each other closely in general appearance and habits, but there is a difference in

the markings of the head, which is usually recognizable. Practically, there is no need for distinguishing them.

The larval life varies in length, according to the season. Dr. Howard mentions sixteen days in May, but this is much longer than is required later in the season. From seven to ten days, during the height of the breeding season, is perhaps the minimum.

When full grown the larva changes to a pupa, which much resembles that of *Culex*, but there is a little difference in the curve, and the breathing tubes on the back are shorter, with a larger, more flaring opening.

The pupal period is given as from five to ten days by Dr. Howard. This was in June, at Washington, and five days is the minimum time given. These observations applied to *maculipennis*, and are too

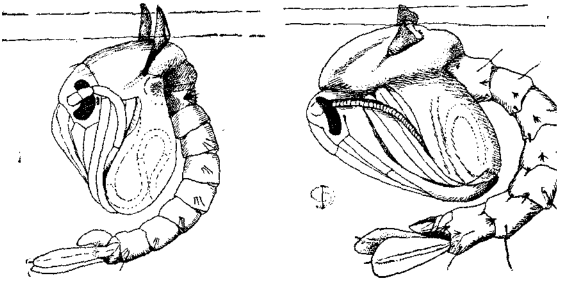


Fig. 31.

Pupa of *Culex pungens* (at left) and *Anopheles maculipennis* (at right), much enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.

long for *punctipennis*, in New Jersey. At Bordentown, Mr. Brakeley reared a series of specimens June 17th, all of which required three days only. June 19th, another lot emerged in several hours less—not much over two days in any case. June 28th, of a lot of larvæ collected, one pupated and produced an adult that same night—a period of less than eighteen hours. July 1st, five pupæ formed at 9 A. M., and from these two male adults issued at 2 P. M.—a period of five hours. This is the minimum period observed, but of the large numbers bred by me in the laboratory, few remained as long as forty-eight hours in the pupal stage. It is almost certain that with all mosquitoes the occurrence of any adverse conditions hastens develop-

ment, and I am quite sure that the whole life cycle of this species can be compressed into a period of ten days, or even less, in case of necessity.

Further facts concerning the habits and modes of life will appear incidentally under other headings.

As to the number of broods occurring during the season, it is impossible to speak definitely. Development is so irregular that in permanent breeding places all stages can be found at any time during the summer, and broods, strictly speaking, do not occur. When a female is ready she oviposits, whether her sisters of the same brood are in condition to do so or not, and so we have a continuous development of adults throughout the summer and lasting far into the fall.

Where Does Anopheles Breed?

This can be answered in one word—everywhere! I have had larvæ in the breeding-pails in my back yard and have found no pool so insignificant nor stream too rapid but that somewhere in it *Anopheles* can breed. Nor is it confined to any one part of the State. Swarms of larvæ are in the waters of the "Pines," in Ocean, Atlantic and Cape May counties and near the top of Mt. Olive, in Morris county, 1,100 feet above the sea level. And it need not even be fresh water, for Mr. Dickerson, in his collections on the Elizabethport meadows, found the larva of *A. punctipennis* in decidedly brackish water, in which it was bred to maturity in the laboratory. For its range of breeding places *Anopheles punctipennis* is thus unequaled by any other mosquito in the State; but I have never found it in cesspools, nor in woodland springs. It does occur, however, in streams taking sewage, where the water is really filthy and grease-covered. Ordinarily, the larvæ do not occur in large numbers at any one point; but even that is not universally true. Mr. Dickerson reports on a puddle, three feet by ten feet, along the roadside, toward Budd's lake: "The water may have been of some days' standing, as there had been several showers in the past few days; but that it was rain water was evident from its character and the situation of the puddle. I was surprised to find *Anopheles* in such a situation on top of the mountain, in a mud puddle, and more surprised at the number—more than I had previously found in any one place." The wind had driven them toward one end of the pool and there they simply covered the surface. A number were bred and proved to be *A. maculipennis.* During the months of June, July and August Mr. Brakeley made a systematic investigation of

all the creeks near Bordentown and found *Anopheles* larvæ in all of them, from the little spring at the head to tidewater. On one occasion when I was with him larvæ were taken from the spring when there was hardly enough water left to dip up. Yet among the grass at the edge and under the shelter of a fence rail larvæ were found. So it was in every puddle to the point where the creek had water enough for a continuous flow. Then frogs, tadpoles and other things came in and mosquito larvæ sought shelter among the grasses or in a quiet bay. Living as they do on the surface, they are satisfied with very shallow water, and, resembling somewhat the little floating masses of *debris* always found among the vegetation, they easily escape notice. Three creeks were thoroughly collected over, and, though they differed in character of bottom and banks and rapidity of flow, *Anopheles* was found everywhere, if nowhere in very large numbers. But it was not in streams, creeks and "babbling brooks" alone that larvæ were found—in little runs at the foot of the railroad embankment and in the more or less connected puddles, so commonly occurring there, they also lived. This is a point that I verified in many other places, and almost invariably mosquito larvæ were found. Good railroad building provides for a drainage of the roadbed, and there are many places along lines where there is more or less water at all times. These make excellent breeding places when none else are around.

Near Bordentown are clay-pits and some brick making is yet done there. There are also some abandoned pits where no work is done at this time and where water has accumulated, forming ponds. These also were collected over by Mr. Brakeley and also yielded larvæ of both *Culex* and *Anopheles*—of the latter, indeed, there were both species, *maculipennis* and *punctipennis*. Here, as in some parts of the creeks, there were sufficient natural enemies in the way of toads, frogs, tadpoles and predatory insects, like dragon-flies and their larvæ, to keep down the crop to limited numbers. In fact, it may be said generally that mosquitoes develop abundantly only in such places as have not been stocked with their natural enemies. And this is an important point in the practical side of the question.

On the point of "how long do they breed?" Mr. Brakeley's observations are also interesting. Killing frosts for cranberries, in which the thermometer went well below freezing, came before the end of September, and toward the end of October there had been ice of appreciable thickness during the night. Yet this did not seem to interfere with the development of the larvæ, though the resulting

adults were rarely seen. Mr. Brakeley bred specimens in November from a pond that had been more than once covered with ice one-eighth inch thick!

Mr. William P. Seal, of Delair, N. J., was also good enough to collect material for me, and sent in a large series of specimens during the season. His collecting was quite different from that done by Mr. Brakeley, and on two occasions I was with him through the territory between Palmyra and his establishment in the woods east of Delair. Here the Aquarium Supply Company has a series of stone tanks and large tubs, which form excellent breeding grounds for mosquito larvæ. The country round about is also well adapted for developing these pests, and Mr. Seal, in his collecting experience, has had opportunity to observe their haunts and habits closely.

In sending one lot of larvæ, Mr. Seal calls attention to the variations in color; one kind varies from green to black and is over beds of *Cabomba.* "Such of them as are green we find over *Cabomba* or other green plants in our tubs, and the darker ones in the fringe of brown and dark-green confervæ attached at sides of tubs. The speckled forms are all over the surface." These were also found in the stone ponds where there were no fish. "A very few fish will keep a small pond clear, though no doubt beetle and other larvæ do their share." After a further discussion of their peculiarities he adds: "I would suggest that the horizontal position of *Anopheles* larvæ would indicate the habit of living over masses of plants which come to the surface of the water. From my limited observation of them I would say that is the rational teleological assumption." How well the larvæ have adapted themselves Mr. Seal shows later, as follows: "I find we have been unsuspiciously fostering *Anopheles* in small ponds where we have fish. They are hidden so completely from the fish, and are so difficult to observe among plants at the surface, that they easily escape detection without very close scrutiny. They harbor also in grass on the edges of streams, and are never abundant like *Culex.*

"I imagine that the ornamental ponds in parks and gardens are prolific sources of *Anopheles* supply. In one plant-pond we have top minows (*Gambusia*). In that pond there are no mosquitoes of any kind."

Mr. Seal's sendings continued until November 5th, on which date all stages from half-grown larvæ to pupæ were received.

On the occasions when I went over the collecting grounds with Mr. Seal, one place attracted attention as illustrating the manner in

which mosquito breeding grounds are created. A tide-water creek to the Delaware flows through a marshy or swampy district, crossed by a bridged road and by a railroad embankment in such a way as to cut off a section of the swamp from tide-water connection. On one side of the embankment fish occur and mosquito larvæ are almost entirely wanting; on the other every dip of the net brought out *Anopheles* and *Culex*. An area of several acres has been turned into a mosquito breeding ground by failing to provide the railroad dam with an opening through which the tide might ebb and flow.

The Spread of Anopheles.

It has been stated that *Anopheles* does not fly far, and this statement has been repeated again and again. But "far" is a relative term. It may not cover so much territory as *sollicitans*, but specimens have certainly been found, in some numbers from one-quarter to one-half mile away from any place where they could possibly breed. This seems like a positive assertion in view of the fact that so little is required for a breeding place; but Mr. Brakeley knows every foot of the territory where these insects were found, and he is my authority in this instance. So I have myself found them under circumstances that indicated an even longer flight, and, given this range, there is scarcely a city and certainly not a town in the State that cannot be easily overrun by *Anopheles* from suitable breeding places in its vicinity or even within the town or city limits. Such breeding places, natural or artificial, occur throughout the State.

Anopheles is a house mosquito, *i. e.*, one that readily resorts to shelter, is attracted by light, and will remain in buildings as a matter of choice. In the evening they come to porches and attempt to get through screens. Specimens have been observed working their way through the wire mesh, and in my own bedroom I have found more *Anopheles* than *Culex* during the late summer of 1901. Little is seen of them during the day, and they are not easily started up from their hiding places. But I have been bitten very early in spring in my laboratory store-room, where, evidently, a small colony had found hibernating quarters.

How Does Anopheles Hibernate?

That the species of *Anopheles* hibernate in the adult stage is asserted by those who have studied the subject, and this is undoubtedly true, as a very pretty series of observations made by Mr. Brakeley proves.

During the late winter of 1900–1901, Mr. Brakeley found in the sorting-room of his cranberry-house occasional specimens of *Anopheles*, which he concluded came in with the cranberry crates brought from the storehouse. When they were brought into the warm room they became active, flew toward the windows, and on rare occasions a specimen evinced an inclination to bite. There were no large numbers at any time, but a few were brought in with almost every lot of crates, and these were regularly caught off, so there was no such thing as a double count of the same example. A few specimens were also noted in the dwelling-house, and, altogether, during the season, almost or quite one hundred specimens were taken in and about the house and cranberry sorting-room. All were females.

As spring set in fairly these specimens disappeared. They were evidently out of winter quarters and ready for outdoor life. They were not followed, but in May Mr. Brakeley and myself hunted larvæ in what we considered likely places, finding none. As the season advanced larvæ were found in abundance at other places, and little attention was paid to Lahaway mosquitoes because of Mr. Brakeley's absence in Bordentown. In September observations at Lahaway were resumed, and larvæ were found in small numbers in a little spring pool connected with a larger pond. After the middle of the month specimens began to make occasional appearances at night, and quite a number had been taken by the beginning of October.

Keeping in mind the fact that so many specimens had been found during the winter in the Cranberry House, Mr. Brakeley made rather a systematic search in the storage building, and found in and about the empty crates several hundred specimens during the collecting period. Most of these were in the crates, which were laid flat side down, and were mainly suspended from the upper side. Specimens were also found in other parts of the house, and evidently in a state of semi-torpor. There had been a series of cold nights, in which the mercury went well below the freezing point, and the house was dusky and cold even in midday.

About the 20th of October several tubs, which had been placed bottom side up in the storeroom of the house, were turned right side up, and in each a number of *Anopheles* were noted and taken. Then the cellar under the house came in for an examination, and in three days nearly 1,500 examples were taken. The foundations of the house are of masonary, forming the walls of the cellar, which is divided into three parts. It is feebly lighted at one end by small windows and at the other end from the doorway. The mosquitoes were

everywhere, but least abundant in the further cellar; most plentiful near the door, as if they had come in that way. Behind a pair of doors, in almost absolute darkness, they buzzed about like a swarm of bees, when disturbed. Collecting was done with a lantern from the ceiling, rafters, supporting posts and side walls. They were most plentiful on the ceiling and rafters.

Over 1,000 specimens were sent to me, and all were females. Most of them were very bright, perfect specimens, evidently not flown, and most of them were very plump. On dissection the abdomen was found to be full of fatty tissue, with no food in the alimentary canal and undeveloped ovaries. Pickers' cabins, out-house, wagon-house and cellar of tenant-house were also examined, and in all cases the record was the same—*Anopheles* by the hundred! It is well within bounds to put the number actually observed about the buildings at over 5,000, and nearly 3,000 of these were sent to me. Just when they resort to hibernating quarters is yet undetermined, but it is probably not much either side of October 1st. As full grown larvæ and pupæ were yet found after November 10th, constant additions to the hibernating colony were made to that date at least.

No doubt *Anopheles* hibernates in the adult stage, in the female only, whenever it can find shelter in buildings. With an *Anopheles* population of over 2,000 in the house, and as many more round about, in other buildings, malaria should be a prevalent disease here, but it is not; in fact, the only cases ever known here had been brought in to get well!

But where do they hibernate where there are no buildings and cellars? Mr. Brakeley answered that question as well, and finds them wherever there is an overhanging turf or sodbank or a "varmint" hole in a sloping bank or gully. An area about five miles long and two miles wide was thoroughly surveyed, and under almost every overhanging turf bank *Anopheles* was found, clinging to or suspended from the rootlets. In burrows of small animals, opening on a sloping bank, many were seen or taken, a puff or tobacco smoke causing them to fly out and be captured. All these captures were sent in to me, and all are females. This point is important, because of specimens bred at about the same time, as many were males as females. The males perform their functions in life at once, and the impregnated females resort to hibernating quarters, leaving the males to die.

This hibernating habit has another important bearing. In warmed

houses dormancy does not become complete, and individuals are liable to be bitten at any time during the winter. This explains some cases of malaria developing at that season, and usually cited to show that there is no connection between the insect and the disease.

Mr. Brakeley, in his notes, from which I hope to give interesting extracts in a future report, speaks of what he calls a "hibernation

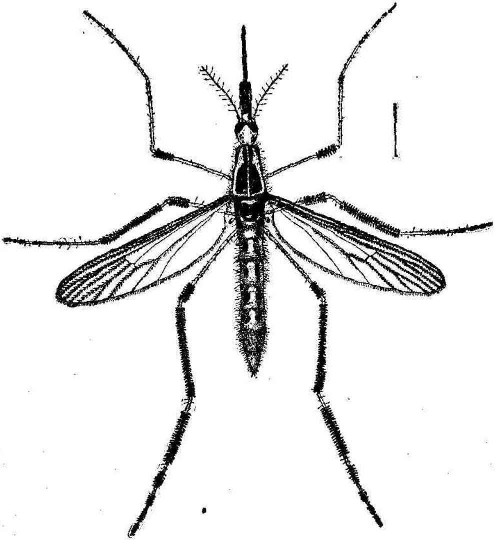


Fig. 32.

Psorophora ciliata, female, enlarged. (From Howard, Bull. 25, n. s., U. S. Dept. Agl., Div. Ent.)

squat." It is a method of resting that resembles, yet differs from, that figured as the normal resting position of the insect. It seems as if the legs were all more closely folded, and the entire insect closer to the surface upon which it is resting than at earlier periods of the season. It is really a preparation for a long, undisturbed

rest, which, under normal conditions, would last until well along in spring. It is perhaps doubtful if *Anopheles* leaves its winter quarters until well along in May, and it comes out then in greatly diminished numbers.

OTHER MOSQUITOES.

Though the species of *Culex* and *Anopheles* are the only ones that need practical attention, they do not constitute our entire mosquito population. We have representatives of three other genera—*Psorophora*, *Conchyliastes* and *Aëdes*.

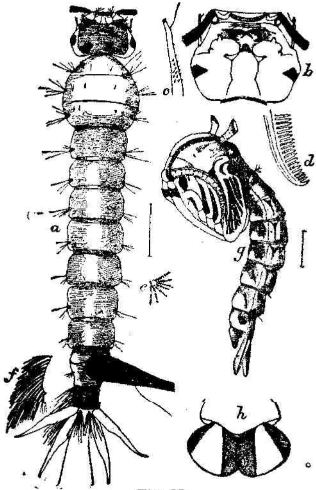


Fig. 33.
Psorophora ciliata, larva, pupa and structural details, all very much enlarged. (From Howard, "Mosquitoes." Copyright, McClure, Phillips & Co., by permission.)

Of *Psorophora* we have one species only, *P. ciliata*, which occurs throughout the State, and is much the largest of our mosquitoes. Its body is fully half an inch in length, and when it is at rest, with its legs spread out, it covers an area of $\frac{3}{4} \times \frac{1}{2}$ inch. The legs are prettily banded and the shanks set with erect black scales, so that the insect is easily recognizable at all times. Its bite is in proportion to its size, and Mr. C. W. Johnson informs me that a coat is no protection. It gets through coat, vest and two shirts without apparent effort, and draws blood promptly. Yet the bite seems not so poisonous as that of *Culex* or *Anopheles*, and certainly the species is too rare to be of much practical importance. Besides, it favors woodlands for its habitation and horses for food, attacking them in

preference to the human beings in their company. On this point Mr. Seal is authority.

The larvæ are immense for wrigglers, and are at once recognizable by their size. Unlike those of the other genera, they are predaceous, and, if food is scarce, also cannibalistic. If half a dozen are placed together in a breeding jar only one will remain at the end of forty-eight hours. I have tried that with specimens taken by Mr. Dickerson on the east bank of the Raritan river, opposite New Brunswick. A single specimen placed in a jar with *Culex* will devour every one of the latter. According to Dr. Howard's observations the small *Culex* larva is simply swallowed entire—the larger larvæ are seized just below the anal siphon or breathing tube, to choke them, and when the struggles cease are devoured to the head. The larvæ are therefore scattered, as compared with those of other mosquitoes. Mr. Seal makes it as about 1 to 1,000 of *Culex*, where they occur together.

Mr. Seal has sent me from time to time, during the season, specimens of larvæ, and, according to his observations, they always come in areas freshly filled by rains, after a previous drought has killed off fish, tadpoles and other predatory insect larvæ. It is obvious that so large a wriggler as a *Psorophora* larva would fall a ready victim to any such forms.

The life cycle is very short and the development exceedingly rapid. Mr. Seal writes: "On one occasion it began to rain on Monday *morning, and water soon collected in the bed of a dried-up pond.* In the deepest place there was a patch of damp mud with a rotten log lying in it. On Tuesday there were thousands of *Culex* larvæ about one-eighth of an inch long, and a few *Psorophora* about a quarter of an inch long. Pupæ of both forms had developed by Friday, and on Monday all had emerged. The development after the first twenty-four hours appears to be proportionally slower, adding force to the suggestion of a possibility of oviposition and some development in the egg before the rain began."

Mr. Seal's suggestion is that, while the larvæ undoubtedly need water for their development, the eggs are not necessarily dependent on it: "The sudden appearance of larvæ after a rainfall suggested the possibility that mosquitoes may be weather-wise and that their eggs may be deposited in the mud, in damp, dark places, where water is always sure to collect, as for instance, under logs, lily leaves, etc., some time before rain actually falls. As the eggs of the mosquito simply float on the surface, there is no reason why they should not develop while resting on a bed of mud, from which

they could absorb whatever moisture they might require, if that were a necessity."

Some information communicated to me by Dr. Howard, concerning *Stegomyia fasciata*, the "yellow-fever" mosquito, and some observations made by Mr. Brakeley on the egg-laying habits of *Aëdes*, give additional support to Mr. Seal's belief, as does an observation of my own. On one occasion I reached a seaside hotel before midday, in a heavy rain, which precluded collecting that day. There had been a preceding dry period, and the downpour continued with interruptions during the night. Next day it continued cloudy, with occasional showers, but I tramped the meadows in gum boots shortly after 10 o'clock. I found in a grassy area about one inch of water, and as a mere matter of curiosity dipped up a small glassful. To my surprise it proved to be swarming with recently-hatched larvæ of *Culex*, none more than an eighth of an inch long, and these were spread over an acre or more. The meadow was only a little lower than the bounding roads, and nowhere was there more than a three-inch depression. I was assured that there had been no water before the rain began the day previously, and informed that a filling up like this occurred with every heavy shower and lasted several days, varying according to the succeeding weather. After three days the water had not lessened materially because it continued cloudy, and the larvæ were then more than half grown. It seems probable now that eggs were already in the meadow before the rain began and that they hatched as soon as there was sufficient water for their support.

Of *Conychyliastes* we also have one species, *C. musicus* Say. It is rather a pretty insect—black in general effect, with white, scaly markings, and the last two joints of the hind tarsi white. The wings have an iridescent appearance, and, altogether, it strikes the collector at once as different from *Culex*. Only three specimens were taken by Mr. Dickerson at South Orange, and we know nothing of the early stages.

Of *Aëdes* we have three species, which differ greatly and have all received separate generic designations. I hold them under one term for convenience here and because they are all small mosquitoes, which rarely, if ever, bite, and are of no economic importance.

A. fuscus is an obscure, brown species, very rare in New Jersey, of which a single specimen has been bred by Mr. Brakely, at Lahaway.

A. sapphirhinus is a beautiful little creature with metallic blue lines on the thorax. Mr. Brakeley has taken this also at Lahaway in a

single example, but has not bred it. It has been bred by others, but I have had no larvæ for study.

A. smithii is a small black form, which, curiously enough, is confined in New Jersey to breeding in Pitcher plant leaves. Mr. Brakeley has made out the complete life history of this species, and he is the first to do this for any representative of this series. It is the only form of which we know that winters in the larval stage, and that it stands repeated freezings and thawings without harm.

The eggs are laid singly, in newly-opening leaves of Pitcher plants, even before there is water in them, and the larvæ develop in the liquid that accumulates when the leaf is fully opened. Interesting as the life history is from the biological standpoint, it can be only briefly referred to here. It proves, however, that the insects, *even when they have the choice, do not always seek water in which* to deposit the eggs, but recognize a suitable locality for the future development of the larva. It proves also that freezing temperatures are not sufficient to destroy life in so highly organized a form as a mosquito larva, *even when it involves absolute exclusion from air for* a considerable period. Another marked peculiarity is that the larva is not dependent upon outer or atmospheric air even in summer. I noticed that in laboratory cultures, and Dr. Howard subjected a lot of larvæ that I sent him to the test of covering the surface of the breeding jar with oil. They lived unharmed for thirteen days in this oil-covered water, which should have killed instantly any example attempting to get at the outer air to breathe in the ordinary manner.

Besides the species already enumerated, which represents all the bifting forms, there is a genus *Corethra*, in which the proboscis is not developed and which is not of economic importance. Of this genus one species has been bred by Mr. Brakely and myself, from Lahaway, which proved heretofore undescribed and which has been named *Corethra brakeleyi*, in recognition of the valuable work done in the direction of increasing our knowledge of these interesting creatures.

REMEDIAL MEASURES.

It will strike the observant reader that I have omitted references to many interesting points in the mosquito economy, such as their song, their natural food aside from blood, and the like. This is not because I do not appreciate their importance nor because I have no information concerning those matters. They simply have no direct bearing

upon the practical question of how the mosquito may be lessened or almost completely abolished. It will appear obvious to those who have followed carefully my discussion of the species that a plan calculated to reach *Culex pungens* and *sollicitans* will, incidentally, reach most *Anopheles* and all the other species of *Culex* that are likely to be troublesome.

In the discussion concerning *sollicitans* it appears clearly that the matter of dealing with the mosquito pest is not a local one in all cases. For instance, nothing that could possibly be done at Berlin

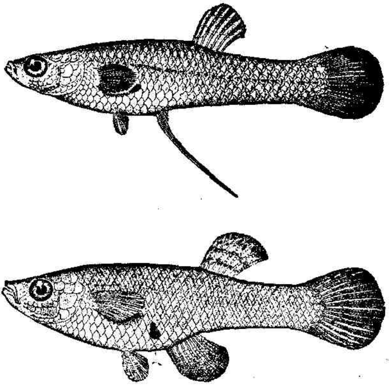


Fig. 34.
Top minnow, *Gambusia affinis*, a little enlarged; male above, female below. (After Jordan & Everman; from Howard, "Mosquitoes." Copyright, McClure, Phillips & Co., by permission.)

would relieve them from the invasion by the salt marsh forms, though they destroy absolutely all possible breeding places within the town limits. Yet local work is absolutely necessary in many other cases and will repay well all expenditures made. But such work should be intelligently done, else much of it will be wasted. The treatment of running streams or of bodies of water in which fish, frogs or other aquatic animals live, or can be made to live, is unnecessary, and even some cases absurd—particularly if the agent

employed is destructive to fish, for then the natural checks are destroyed and any lapse or defect in the artificial treatments will result in greater trouble than ever. The rational method is to assist the natural checks so far as may be and employ destructive agents only when permanent works fail to give relief. For instance, it will pay better to fill a depression in which rain water habitually accumulates with a load of sand than to treat it with oil every two weeks during the summer and every year in succession. And it will pay better to stock a pond with proper fish and trim its banks, to do away with places inaccessible to them, thau to spray it periodically with oils or the like.

The first essential in my plan of control, therefore, is to ascertain all the natural checks and the methods by which they may be made most effective. This will require a careful bilogical survey of the water inhabitants of the State, that I may be able to make definite recommendations as to just when matters may be left to nature and when active work must be undertaken. It is this survey that requires a large part of the money appropriation elsewhere mentioned, and it will involve the study of the habits of certain fishes as well as of the mosquito larvæ. We are not entirely without information on this point, as the following from Mr. Seal will demonstrate:

"Among the fishes common to New Jersey there appears to be none that can be depended on to become by a general distribution destroyers of *Anopheles* larvæ. The sunfishes, comprising many species, large and small, are undonbtedly, in the waters in which they abound, great destroyers of *Culex* larvæ; but it is doubtful whetber they are of much value in the case of *Anopheles*, as they are not top-feeders. Further south—though probably a summer visitor to the coast of New Jersey—there is a small species which, feeding on the surface of the water, is sure to capture such larvæ as must come to the top for air. This is the little viviparous top-minnow (*Gambusia affinis*), one of the smallest of our fishes, the largest of them being only about $1\frac{3}{4}$ inches long and quite slender. Skimming the surface of the water in schools, nothing escapes them. During the past summer two small artificial ponds, stocked with plants, were inhabited hy *Gambusia*, and in them mosquito larvæ of any kind have been sought for in vain. In other ponds, inhabited by goldfish, both *Culex* and *Anopheles* could always be found.

"Dr. H. M. Smith, in charge of the division of scientific inquiry of the U. S. Fish Commission, states that he has opened large num-

bers of *Gambusia* and found their stomachs filled principally with mosquito larvæ.

"Where these fishes occur they exist in great numbers. They may be found in water so shallow it will just cover them, and they will follow a water-course to its source if there is enough of it to allow them to swim.

"Dr. L. O. Howard, in 'Mosquitoes,' quotes Dr. Veazie, of New Orleans, concerning the value of *Gambusia* as destroyers of mosquito and other larvæ. The writer confirms this value from the standpoint of several winters' observations about Southern cities, as well as by experiments at home.

"In dealing with *Anopheles*, account must be taken of the ornamental ponds in our parks and private estates, the dense aquatic and

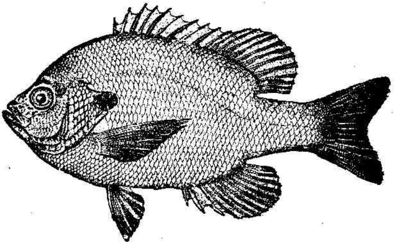


Fig. 35.
Common sunfish, less than natural size. (After Jordan & Everman; from Howard, "Mosquitoes." Copyright, McClure, Phillips & Co., by permission.)

semi-aquatic foliage of which becomes a prolific source of supply for this genus.

"Water hyacinths, reeds, rushes and other aquatic plants protect them from fishes in general, and somehow they seem to escape the predaceous insects as the other kinds do not, for, no matter if there are fishes of the most voracious character and swarms of destructive beetles and their larvæ, *Anopheles* can always be found, even if in small numbers.

"It therefore seems probable that any attempt to reduce the numbers of *Anopheles* should contemplate the general introduction of *Gambusia affinis*, and as it is a work which, to be effective, must be

Fig. 36.

View of swamp in South Orange after treatment with Phinotas oil. The white appearance of the water surface is due to the oil. From a photo.

general, it should be considered whether our Fish Commissions should not be media for their collection and distribution.

"During the summer months *Gambusia* may be found in great numbers in the salt marshes of the coast and in the ditches and brackish ponds adjacent to tidal streams as far up as brackish water extends. The extreme northern limit for them is probably the vicinity of New York. In the fall the aquarium dealers there have them in large numbers, probably bought of boys who catch and sell them.

"The question of whether *Gambusia* would stand our northern winters would have to be determined by experiment. It has been demonstrated that some water plants not to be found north of North Carolina will not only withstand the northern winters, but will quickly drive out other forms that are indigenous, showing that environment is probably in nature more often a matter of choice than necessity.

"*Gambusia* is rarely found out of brackish water, but it lives and multiplies as readily in absolutely fresh water, as has been demonstrated by the rearing of four or five generations of them in fresh water, in tubs and small ponds."

Mr. Seal's communication deals chiefly with *Gambusia* as an effective agent in controlling *Anopheles*, and as this is the form in which sanitary authorities are most interested, it is well to know that by opening up channels by means of which this little fish can get into all parts of such marsh areas as the Elizabethport and Newark meadows, their importance as breeders of disease-spreading mosquitoes can be materially reduced.

I have noted on a previous page that wherever the tide ebbed and flowed, even if at ebb only puddles were left, the swarms of little fish left in these pools effectively prevented mosquito breeding. As against *Culex* larvæ, sunfish are quite effective in any bodies of water not too much overgrown and not too shallow at the edges, and these flourish all over the State. I have verified this again and again in ponds and ditches inhabited by them about cranberry bogs, which would otherwise have been excellent breeding places for mosquito larvæ.

Therefore, running streams and permanent ponds or water bodies should not be treated with oils or other material destructive to fish or other aquatic life. Let us rather foster the fish or even the frogs and toads by clearing up permanently the places inaccessible to them. Not only will this be in the long run the cheapest method, but it is

also much the most effective. On this point Mr. Seal, who has had personal experience, writes as follows:

"By reason of their adaptation to an environment affording greater protection, the various species of *Anopheles* enjoy a greater immunity from destruction by fishes, tadpoles, aquatic insects and their larvæ, and from the coal oil treatment, than do those that live in the open.

"*Anopheles* is the first to appear after coal oil has been applied, and if the oil is not carefully worked by agitation among the grasses and weeds bordering the shallow edges of ponds, and into the animal tracks holding water around the margins, the chances are that a great many mosquito larvæ will escape destruction."

The center of a pond or stream of any size affords no breeding place for mosquito larvæ. They do not, or perhaps cannot, exist in the ripple area.

It is probable that more thorough investigation will indicate other natural checks of which we may take advantage.

A second part of my scheme for controlling the mosquito pest in New Jersey is the destruction of their natural breeding places so far as is possible, and this involves the study of the best methods for such destruction under varying conditions. Some are obvious enough: the filling-in of sunken lots containing stagnant water in cities and towns, especially in the outskirts, and the frequent flushing of city drains and gutters. These are local affairs and may be left to the boards of health or other authorities, but the requisite information for intelligent action should be placed before them in succinct form. Drainage of marsh and swamp areas, including the immense extent of salt marsh previously described, is also desirable, and, if we are to do away with the most troublesome of our species, some treatment of the latter is imperative.

At first sight this problem seems beyond our power without the expenditure of immense sums of money; but when we come to study it more closely it becomes less formidable, and we will find many interests, not only willing, but anxious to assist. I have shown that not only owners of shore property, but communities for miles inland, are involved, and that it is a State, rather than a local matter, though the local authorities must assist. As the local interests in shore resorts are of immense value and will be increased many times if the mosquito pest be controlled, no difficulty is likely to be experienced in securing their co-operation. Many of these interests have already expended considerable sums in this direction with generally good results. Thus, at Seaside Park every breeding place

for *sollicitans* has been abolished by grading and filling, so that in a two-day search I found not a single larva.

Treatment of two kinds is indicated: First, providing free access for ordinary tides to all parts of the marshes, and drainage from areas flooded only at ordinary storm or spring tides. It is not necessary to drain the areas in the sense of leaving them permanently dry, though this will be the ultimate result when they are made habitable. *It is* only necessary, at first, to do away with those stagnant areas whose connection with the sea is intermittent. The simplest kind of ditching is often all that is necessary; but it needs an investigation to show where those ditches should be and what areas are of greatest importance. Second, filling in or grading, in those areas where only winter storm tides leave pools, which last until June or July and in which the early supply is produced in countless numbers. No enemies of mosquito larvæ occur in such pools, and breeding is absolutely unrestrained for weeks. At Anglesea I found one such area in June, which had become so reduced that a single load of sand would have filled it, but in which several thousand larvæ and pupæ were swarming and from which had emerged many times that number of adults then resting on the grasses around about. A few days' work for one man with a shovel and wheelbarrow would have abolished that whole area, material for the filling being immediately at hand in the form of sand-hills. This sort of work is within the province of the communities where such areas exist, and owners of hotels could, at the expense of only a few hundred dollars, do away with all breeding places of this character in a considerable territory. It has been already stated that at Seaside Park such work has been successfully accomplished and the local supply has been completely eliminated.

The importance of a material lessening of the mosquito pest to the cities of Jersey City, Newark, Elizabeth and to the surrounding towns can hardly be over-estimated, and such a study as is contemplated by me would indicate just what measures should be taken to obtain this desirable result.

There remains a class of cases which must be dealt with by local and sometimes individual action. That is where the insects breed in rain barrels, cisterns, temporary pools, cesspools, liquid manure pits, sluggish ditches and the like. These are not always amenable to general treatments, and in such cases destructive agents must be employed.

The simplest of these is petroleum, which may be either the crude

product, the refined kerosene, or a fuel oil, which is cheaper than either and equally or even more effective. Sprayed over the surface of a pool, it forms a continuous film, which is fatal to the adult attempting to lay eggs and to the larva coming to the surface to breathe. It remains effective as long as the surface film is unbroken, but if at all exposed to the wind is apt to be driven to one side or end, and eventually to the shore, into the ground. It requires frequent renewals, therefore, and, as Mr. Seal has already shown, must be very carefully used if satisfactory results are to be obtained. In covered or sheltered places it will afford protection for a long time. In rain barrels it will not interfere with the water if drawn from below, and will not, ordinarily, result in the death of fish if any are in treated pools. It requires about one ounce for fifteen square feet of water surface.

Another material which has been used during the past season in South Orange is "Phinotas Oil," a mixture prepared by the Phinotas Chemical Company, of New York City. It is priced at 40 cents per gallon, with special discounts, and is applied in the form of a coarse spray. Its composition is unknown to me, but, judging from its effect and its odor, seems to contain carbolic acid. Sprayed on the surface, it sinks to the bottom in large globules and gives off a whitish material, that rapidly turns the water milky. In a few moments the globules rise again to the surface, burst and spread an oily film in every direction. This milky solution is rapidly fatal to mosquito larvæ and to aquatic life generally, including fish. In laboratory experiments I found that even a small percentage of the milky water, added to a jar of mosquito larvæ, killed them in a very few minutes, while any large amounts killed almost immediately. This active effectiveness remained for two weeks and may continue longer, but my tests were not carried beyond that point. There can be no question, then, as to the killing qualities of this material, and for use in cesspools, stagnant water areas, manure pits or offensive breeding places generally, there is nothing better or lasting. But it cannot be employed in rain barrels or cisterns, where the water is to be used for domestic purposes. Nor is it advisable where there are fish, for if these be destroyed with the predatory insect larvæ, etc., dependence upon artificial checks becomes absolute, and any failure to make timely applications will result in mosquito swarms greater than ever.

Of course, the question whether all this is really practical will be be asked at once. I have no doubts in the matter myself, and my

opinion is borne out by those who have studied the subject longest. Dr. L. O. Howard, from whose work on mosquitoes most of the illustrations here used have been obtained, is quite emphatic on this point, and quotes approvingly a statement that there seems "to be no more reason for enduring the mosquito scourge than in allowing smallpox to ravage communities, as it used to do before the days of Jenner."

On Long Island an area embracing 70 square miles has been under treatment during the summer of 1901. A large area of marsh land was "reclaimed" in the vicinity of Boston in 1900. In Connecticut, as I am informed, a considerable territory along Long Island Sound has been made habitable by destroying mosquito breeding places. The work done at and near Havana by the Marine Hospital Service has been remarkably efficient, and good results seem to have been obtained on Staten Island by Dr. Doty.

No attempt has been heretofore made to clear a State of these pests, but so many local attempts are now under way that it becomes important to show just what can and what cannot be done by such work.

I do not wish to be understood as attempting the *destruction* of the mosquitoes in the State of New Jersey with an appropriation of $10,000 or any other sum.

I wish to be understood as claiming that with such an appropriation it will be possible for me to make such a study of the subject as will enable me to present a consistent plan of action, which will show just what can be done by the individual, the local community and the State—a plan which will attain the result slowly or rapidly, in proportion to the energy or listlessness with which it is carried out, and which will prevent discouragements and failures due to attempts to accomplish the impossible. All this I believe may be done, and I can see no reason why, inside a decade, New Jersey mosquitoes should not be reduced to such a point as to be practically unnoticed. Extermination, be it noted, is *not* claimed. The plan contemplates permanent relief, based upon intelligent activity, along well-defined lines.